POWER PLANT ENGINEERING

Established Over 35 Years

VOL. XXXV CHICAGO, JULY 15, 1931 No. 14

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Published on the 1st and 15th of each Month by the
Technical Publishing Co., 53 West Jackson Blvd., Chicago
New York Office, 171 Madison Avenue

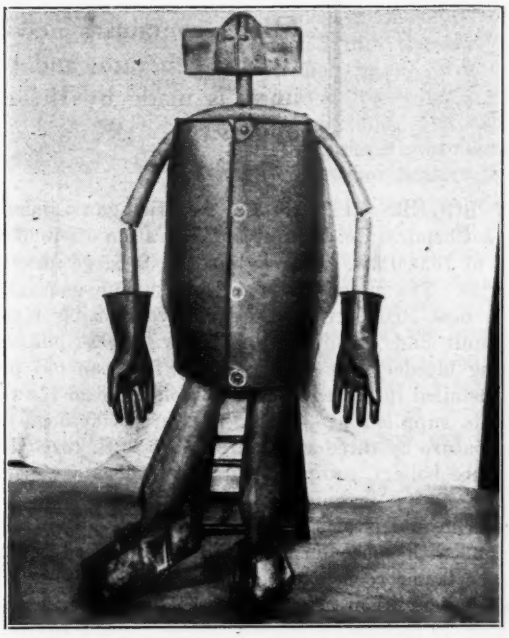
Subscription price $2.00 a year in the United States and possessions. Canada $2.75 a year. Other countries $3.50 a year. Single copies 15 cents.

Copyright 1931, by Technical Publishing Co.

Entered as second class matter May 1, 1908, at the Post Office at Chicago, Illinois, under the Act of March 3, 1879.

Member, Associated Business Papers, Audit Bureau of Circulations.

Circulation of this issue 23,950



The Wizard of Ohms

. . . . AND SO, at last, Dorothy was ushered into the august presence of the great Wizard of Ohms. How she trembled! How her heart beat, and how little Toto struggled and nearly jumped out of her arms when he beheld this strange rubber man sitting there silently.

Yet, Dorothy was not frightened; for in her terrible, long journey through the dreadful Land of Volts, where the sleek, sizzling tentacles of the deadly kilovolt reached out at her from every current bush and where the vicious power trust lay in ambush behind every electric plant, had not this man protected her? Had not his resistive influence saved her? Indeed, it was said of this man that no potential, however great, had ever dared attack him. He had merely to put forth his rubber hand and the most vicious snapping kilovolt would recoil in terror, such was his resistance. Indeed, this man, to one of Dorothy's gentle nature, need not be feared in the least and so, though she trembled, she approached him boldly, confident that he would grant her request to conduct her to her home in Missouri.

And conduct her to Missouri he did for that was where he himself hailed from. A large power company down there, it seems, made him just for fun out of the rubber devices used by their linemen when working on high voltage equipment. Having made him, of course, he had to pose for a photograph and that is how he became a part of this article. More of his life's history will be found on page 765.

Michigan Limestone & Chemical Co. Builds 16,000-Kw. Power Plant

Power Plant to serve limestone quarries at Rogers City, Mich., contains a new 10,000-kw. condensing bleeder turbine generator and a 6000-kw. unit. Steam for these units is made by three 880-hp. stoker-fired bent-tube boilers.

AT ROGERS CITY, Mich., the Michigan Limestone & Chemical Co. has put into operation a new power plant of 16,000 kw. capacity to serve its large limestone quarries. The plant contains two turbine-generators; one a new 10,000-kw., 3600-r.p.m. condensing bleeder type unit and the other a 6000-kw., 3600-r.p.m. condensing bleeder type unit removed from an old plant and installed in the new turbine room. Steam for these units is supplied at 375 lb. pressure, 700 deg. total temperature by three stoker-fired 8800-sq.ft. three-drum bent-tube boilers, equipped with air preheaters.

The station is built of brick and steel with limestone trim and is of simple yet attractive design. It is laid out with space for one additional generating unit and the boiler room can be readily extended for additional boilers when needed. As the plant operates condensing, it had to be located where a good supply of circulating water is available. This location was found on the shore of Lake Huron where the water is free from contamination and has an average temperature below 50 deg.

New Turbine-Generator Is a 3600-R.P.M. Unit

The turbine room is at the east end of the power house, divided from the boiler room by a brick wall. Here the new turbine generator unit is placed with its condenser, as shown in Fig. 1. The turbine is rated at 10,000 kw. and operates at 3,600 r.p.m. This is considered in this country to be a large turbine for this speed and it is seldom that an industrial plant installs such a unit. Turbines for 3600 r.p.m. are not in any sense an experiment, however, as they are used in central stations in sizes up to 15,000 kw. and in many industrial plants in sizes of 1000 or 2000 kw. The operating results at Rogers City have indicated so far that the unit will deliver satisfactorily the services demanded of it.

This turbine is a 21-stage unit taking steam at the throttle at 375 lb., 700 deg. total temperature. It is equipped with four bleed points for extraction of steam for feedwater heating and building heating.

Steam Extracted from Turbine Heats Boiler Feedwater

The accompanying tables show the general steam conditions under which this turbine was designed to operate either with extraction for feedwater heating only or with extraction for the heating systems. When no heating steam is extracted and the turbine is operating at 10,000 kw. gross output, 5330 lb. of steam an hour is drawn for feedwater heating from the No. 3 bleed point at about 30 lb. absolute pressure and 10,190 lb. an hour from No. 4 point at about 10 lb. absolute. Under these conditions about 100,000 lb. an hour of steam is supplied to the throttle and about 85,000 lb. an hour passes to the condenser. For 10,000 kw. gross output of the turbine, its water rate is designed to be 9.40 lb. per kw-hr. The plant water rate at this load is 10.55 lb. per kw-hr.

When the heating system is to be supplied, 15,000 lb. of steam an hour is taken from No. 2 bleed point,

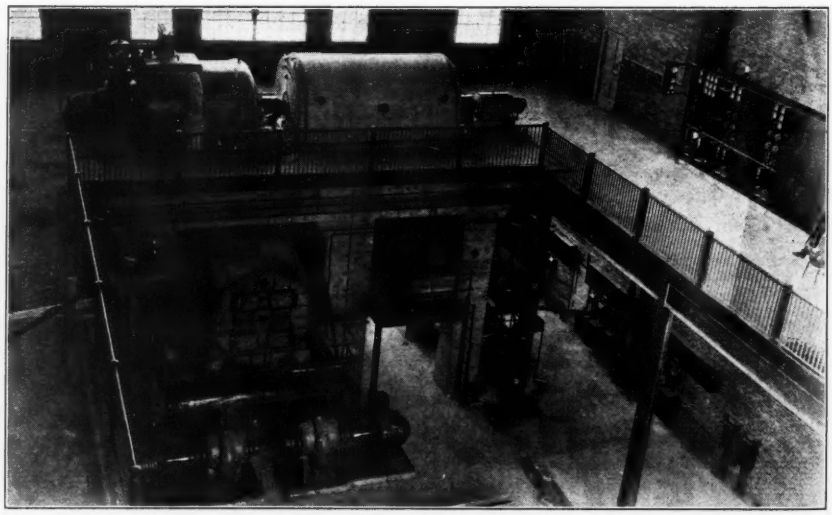


FIG. 1. GENERAL VIEW OF TURBINE ROOM, SHOWING 10,000-KW., 3600-R.P.M. TURBINE-GENERATOR, CONDENSER, CIRCULATING PUMPS AND SWITCHBOARD

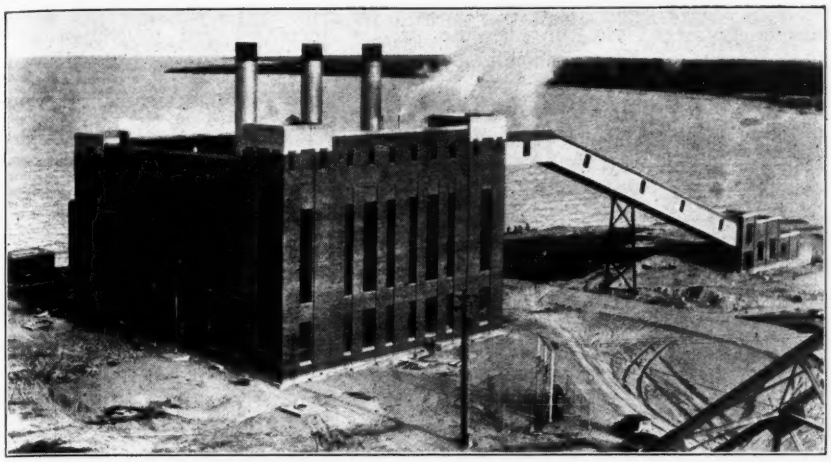


FIG. 2. THE NEW POWER PLANT HAS THE PLEASING STYLE OF A SMALL CENTRAL STATION. INCLINED BELT CONVEYOR AT RIGHT CARRIES COAL TO BOILER HOUSE BUNKERS

in addition to that extracted from Nos. 3 and 4 for feedwater heating. This bleed point at 10,000 kw. load is at about 70 lb. pressure absolute and is throttled for heating steam supply to about 65 lb. absolute or 50 lb. gage. Heating system steam is desuperheated, if necessary, and sent through an 8-in. pipe line to the various buildings.

The tables show the variations in the pressures and steam quantities under various conditions of turbine load from 12,500 kw., which can be obtained from the unit at 1.0 p.f., down to 2500 kw. Data on the turbine water rates are given in the list of equipment.

Condenser and Extraction Heater Details

Condensing surface of 10,000 sq.ft. for this turbine is provided by a 2-pass radial flow condenser, for which two 7300-g.p.m. centrifugal pumps supply circulating water. When condensing 100,000 lb. of steam an hour with 11,700 g.p.m. of 55-deg. water, this condenser is designed to produce 1.00 in Hg. absolute back pressure or 29 in. vacuum.

Figure 4 shows the flow of steam, condensate and makeup boiler feedwater.

Circulating water is drawn from Lake Huron through a revolving screen, passing through a 4-ft. diameter cast iron pipe into a suction well from which the condenser circulating pumps force it through the condenser. It discharges from the condenser into a concrete discharge canal and passes through another 4-ft. cast iron pipe back to the lake. Provision is made for re-circulating warm discharge water to the intake to melt ice in cold weather.

Duplicate condensate pumps, 270 g.p.m. each against 114 ft. head, send water from the condenser hotwell through generator air cooler to two extraction feedwater heaters. One of these is designed to heat 120,000 lb. of water an hour from 80 to 178 deg. F. using steam from bleed point No. 4 at about 8.5 lb. absolute. The other is designed to heat 120,000 lb. an hour from 178 to 227 deg. with steam at 26 lb. absolute from No. 3 bleed point. From these heaters the water passes to the boiler feed pumps which are 300-g.p.m., 4-stage centrifugals, two motor-driven and one turbine driven. Makeup water, which is 4 per cent of the total, is taken from Lake Huron, filtered and softened with a zeolite water softener.

The makeup water is added to the system from the softened water storage tank by injection into the main condenser above the tubes, thus insuring deaeration. The quantity of makeup water admitted into the system is controlled by a valve operated by a low water float in the surge tank. The condensate is pumped through the two feedwater heaters to the boiler feed pump suction or into the surge tank which floats on the line. The surge tank is of ample capacity to take care of all fluctuations in feedwater between the boilers and turbines. An emergency overflow from the surge tank goes to the softened water storage tank. In normal operation, the height of water in the surge tank shows little variation and there is no danger of oxygen absorption due to the temperature of the water and also due to the fact that there is little movement of the water into and out of the surge tank.

Power Generated at 13,800 V. Goes Direct to Quarries

Generation at this plant is at 13,800 v., 3 phase,

TABLE I. HEAT BALANCE, 10,000-KW. UNIT, MICHIGAN LIMESTONE & CHEMICAL CO. EXTRACTION FOR FEEDWATER HEATING ONLY

Steam to throttle at 375 lb. 700 deg. F - No heating steam - 29 in. vacuum					
Gross Mach.Output-kw.	12,500	10,000	7,500	5,000	2,500
Net Plant Output-kw. D.S.	11,875	9,500	7,050	4,600	2,200
Per Cent Auxiliary Power	5	5	6	8	12
Power factor on Generator	1.00	0.80	0.80	0.80	0.80
Per Cent Makeup	4	4	4	4	4
Steam to Condenser lb/hr.	106,400	85,100	64,700	45,500	26,900
#1 Bleed	0	0	0	0	0
#2 Bleed	0	0	0	0	0
#3 Bleed	5,250	5,330	3,740	2,340	1,132
#4 Bleed	14,280	10,190	6,560	3,640	1,378
Steam to throttle	125,930	100,100	74,700	51,480	29,410
" " jets	720	720	720	720	720
Makeup	5,350	4,160	3,080	54,300	31,560
Steam Press #1 lb. abs.	250	207	154.6	104	58.2
" " #2	88	69.5	51.9	34.9	19.43
" " #3	39	30.4	22.6	15.42	8.65
" " #4	12.4	9.87	7.5	5.15	2.99
Feedwater Temp. from Hotwell	79	79	79	79	79
From After condenser	85	85	85	85	85
" #4 heater	191	181	168	152	130
" #3 "	230	230	214	194	166
Plant water rate lb/kw.hr gross	10.55	10.55	10.51	10.87	12.5
" " " " " " net	11.10	11.10	11.18	11.80	14.2
B.t.u.to steam per gross kw-hr.	12,280	12,280	12,420	13,050	15,340
" " " " net " "	12,930	12,920	13,220	14,160	17,420

TABLE II. HEAT BALANCE, 10,000-KW. UNIT, FEEDWATER HEATING AND BUILDING HEATING STEAM EXTRACTED

Heat Balance for 10,000-kw. Unit Normal Extraction Operation Plus Extraction for Supplying Heating System with 15,000 lb/hr. Vacuum 29 in. - Throttle Steam 375 lb. gage, 700 deg. F.					
Gross Machine Output-kw.	12,500	10,000	7,500	5,000	2,500
Net Plant Output-kw.	11,875	9,500	7,050	4,600	2,200
Per cent Auxiliary Power	5	5	6	8	12
Power Factor on Gen.	1.00	0.8	0.8	0.8	0.8
Steam to Heating Main	#2 bleed pt. throttled to 50 lb. g. 15,000 lb/hr.	#2 B.p. 50 lb.g. 15,000	#1 B.p. 50 lb.g. 15,000	#1 B.p. 50 lb.g. 15,000	Live steam Throttled to 50# g. 15,000
Plant Water Rate lb/kw.hr.gross	11.4	11.57	12.20	13.20	18.5
" " " " " " net	12.0	12.18	12.96	14.35	21.0
B.t.u.to steam per lb.gr.kw.hr.	13,300	13,470	14,400	15,840	22,700
" " " " "net " "	14,000	14,180	15,320	17,220	25,800

60 cycles, so that the quarries located a considerable distance from the plant can be adequately served at bus voltage. The initial installation consists of one 12,500-kv-a. 0.8-power factor generator with building space for two additional units.

The generator has a closed type cooling system and is equipped with direct-connected main and auxiliary exciters. The main exciter has a capacity of 62.5 kw. at 125 v. and is shunt wound, while the auxiliary exciter has a capacity of 2 kw., 125 v. This type of excitation, which is uncommon for industrial generator installations, was chosen on account of the type of load served from this station. This load has momentary swings which vary in excess of 50 per cent, caused by the large electric shovels in the quarries. The power factor of the connected load is near unity and it is thought that the turbine will handle as much as 12,500 kw.

Excitation is controlled by a vibrating type regulator equipped with a positive phase sequence network that insures correct regulator operation for balanced or unbalanced conditions. This excitation scheme is especially adapted for this load, since the separate excitation of this main exciter results in a high rate of build-up of the exciter, which, in conjunction with the vibrating type regulator, gives a high degree of stability and ability to follow rapid load fluctuations.

Switching Equipment

Single bus switching scheme is used in this station, with adequate facilities for sectionalizing with disconnects so that any portion may be removed for inspections or repairs without interruption to service. Feeders and generators are so arranged on the bus that this may be accomplished.

Type B-32 oil circuit breakers are used for all of the 13,800-v. circuits and are installed in a concrete cellular bus structure with interlocked doors. This type of structure was used rather than a metal structure because of the increased fire protection and economies of installation.

Station Service Equipment

Practically all of the auxiliaries at this station, with the exception of one boiler feed pump, are electrically driven by 480-v. motors. Power is obtained for these auxiliaries direct from the 13,800-v. bus through three 500-kv-a., 13.8-kv./480-v. self-cooled transformers installed outdoors adjacent to the turbine room. These transformers are connected delta-delta and are of such a size that the auxiliaries of two units can be carried on the bank connected in open delta. The ultimate scheme for this station provides for a second station power transformer bank and will be installed with the third generating unit.

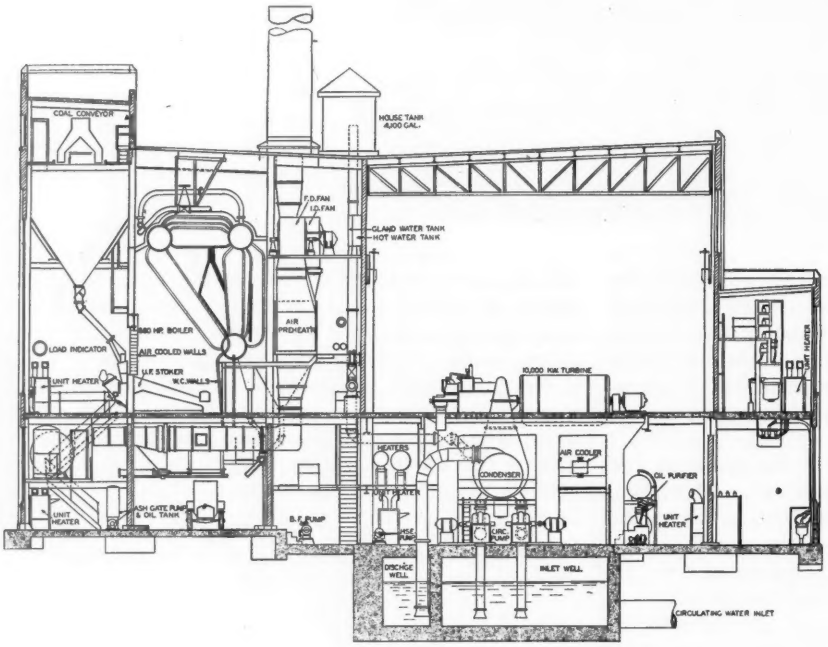


FIG. 3. GENERAL CROSS-SECTION THROUGH PLANT SHOWS STOKER-FIRED 880-HP. BOILER, FURNACE DETAILS, AIR PREHEATER, GENERATING UNIT AND ARRANGEMENT OF ELECTRICAL EQUIPMENT. UNIT HEATERS SUPPLY HEATED AIR FOR COMFORTABLE WORKING CONDITIONS

Direct current from this battery can also be used for emergency lighting but normally the lighting cir-

An air circuit breaker installation is provided for the 480-v. station service circuits with hand-operated breakers on all of the group feeders and solenoid-operated breakers on feeders that serve individual motors. These circuit breakers are mounted on 95-in. slate panels and each circuit is equipped with an ammeter mounted below the circuit breaker. This type of 480-v. installation was chosen on account of its compactness, reliability and over-all economy. Practically all of the constant speed motors in this plant are started at full voltage.

The main control board is located on the turbine room floor adjacent to the 13,800-v. switching structure, Fig. 1. This switchboard is of 90-in. ebony asbestos panels; Type AD indicating instruments are used.

All the oil circuit breakers and a part of the 480-v. air circuit breakers are solenoid operated. Power for operating these breakers is obtained from a 125-v. NHSX-9, sealed glass jar storage battery, charged with a 2-kw. diverter pole type generator.

cuits are supplied with 130 v. a.c. from two small 460/130-v. transformers connected to the station power bus.

Boilers and Stokers

In the boiler room, Fig. 3, are installed three stoker-fired boilers, air preheaters and fans, water softener and boiler feed pumps.

Boilers are of the three-drum bent-tube type, 8797 sq. ft. of heating surface each, with convection superheaters, all designed for operating pressure of 400 lb. and total steam temperature of 700 deg. They are designed to produce a maximum of 80,000 lb. of steam an hour each. They are fired by 8-retort, 29-tuyere power ash dump underfeed stokers. Each stoker has a projected grate area of 182.6 sq. ft. The coal ordinarily burned will be 1¼-in. Pittsburgh nut and slack, with a dry B.t.u. value of 13,500 and ash fusing temperature of 2200 deg. Each furnace has a volume of 2800 cu. ft.; the front walls have grid-type air-cooled wall protection, side walls are refractory and the rear walls consist of 29 plain 3¼-in. tubes, effective length 11 ft., giving an effective heating surface of 145 sq. ft. per boiler.

Coal from the storage pile is loaded by a locomotive crane to the track hopper, into which hopper bottom coal cars can also be dumped. Most of the coal will be received at the plant by water, a coal dock being provided adjacent to the plant for unloading it. From the track hopper, the coal passes over a feeder belt to an inclined belt conveyor, Fig. 2, thence over a weightometer and over the bunkers where a tripper can distribute it. From the bunker, coal flows to the stoker hoppers through non-segregating coal spreaders.

Ash from the stokers drops into a firebrick-lined steel hopper where it is quenched and dropped through oil-operated roller gates directly into trucks for further disposal. Ash from the hoppers under the last boiler pass and air preheater is also spouted to the basement where it can be removed by truck.

Air for combustion is drawn from the upper part of the boiler room by a double-inlet forced-draft fan over each boiler, driven by a 75-hp. 2-speed motor. These fans are driven at 1150 r.p.m. maximum. At this speed and at 7.0 in. static pressure, the fans are designed to handle 34,500 c.f.m. of 70 deg. air. This is forced through a 4555-sq. ft. tubular air preheater, which raises its temperature to about 300 deg. and it passes then to the stoker.

Flue gas passes from each boiler through the air preheater and is discharged by a double-inlet induced-draft fan over each boiler. Each fan is designed to handle a maximum of 80,500 c.f.m., of 550-deg. flue gas at 690 r.p.m. and 5.0 in static pressure.

Above figures are maximum ratings for these fans; the list of equipment shows performance data guaranteed at other capacities. Both forced and induced draft fans are designed to operate the boilers up to 60,000 lb. of steam an hour on the low speed, the higher speed being needed for the maximum boiler output of 80,000 lb. an hour. Each boiler discharges its flue gas through an individual steel stack.

As noted above, the boiler feed pumps, set in the boiler room basement, Fig. 3, are 4-stage, 300-g.p.m. centrifugal units. They are designed for 1035 ft. total head or about 450 lb. at 3500 r.p.m. Two pumps are motor-driven and the third is driven by a single-stage turbine taking steam at 350 lb. and exhausting at 15 lb. gage to the atmosphere. The turbine driven pump is used only as a stand by unit.

Feedwater enters the boilers under the control of thermostatic type feedwater regulators and all water flowing to the boilers is measured by a Venturi meter.

Main steam valves and larger water valves are motor-operated. Reducing valves and desuperheater are provided for reducing steam pressure from 400 lb. to 200 lb. and from 225 lb. to a variable range of 10 to 35 lb. gage for heating system, process work and feedwater heating when live steam must be used for these.

Each boiler is operated from its own control panel, where motor controls for fans and stokers are grouped

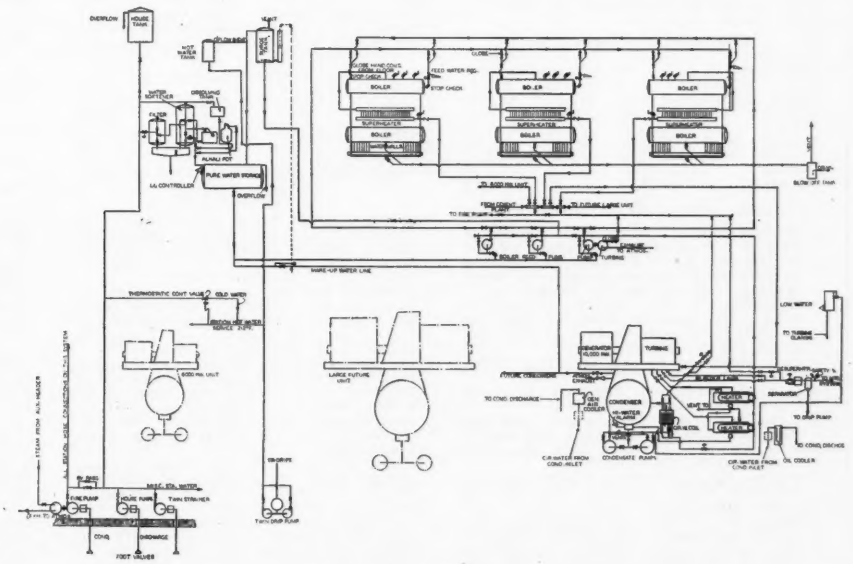


FIG. 4. PIPING DIAGRAM OF STATION SHOWING FLOW OF STEAM, CONDENSATE, FEEDWATER AND THE LIKE. LEVEL IN SURGE TANK CONTROLS DELIVERY OF MAKEUP WATER, WHICH IS INTRODUCED ABOVE TUBES OF MAIN UNIT CONDENSER TO INSURE DEAERATION

Principal Power Plant Equipment

General

Location—Rogers City, Michigan
Service—Electrical power
Capacity—16,000-kw. consisting of 10,000-kw. new unit and 6,000-kw. unit moved from old power plant
Building—106 ft. by 139 ft. approx.
Type of Building—Reenforced concrete sub-structure with steel frame and brick curtain wall superstructure.
Designing Engineer—Allied Engineers, Inc.
Construction—Michigan Limestone & Chemical Co.

Turbine-Generators and Condensers

1 Westinghouse Electric & Manufacturing Co. 10,000 kw., 0.8 power factor, 60 deg. C. rise, 13,800-v., 3-wire, 60-cycle, 3-phase, 2-pole, 3600-r.p.m. turbine generator. Turbine of bleeder type designed for 375 lb. gage at the throttle 258 deg. F. superheat steam. Turbine-generator is complete with direct connected exciter and one 2308-sq. ft. single section, 2-pass Griscom-Russell generator air cooler. Turbine has a steam driven auxiliary oil pump and a 10-in., four-valve steam chest. Four points of bleeding in turbine casing. Performance using 375 lb. gage, 700 deg. F. total temperature steam.

Kw.	Power Factor	Steam Lb. Per Kw-Hr.
2500	80	11.52
5000	80	9.88
7500	80	9.40
10000	80	9.40
12500	100	9.40

1 Westinghouse Electric & Manufacturing Co. 10,000-sq. ft. surface type, 2-pass, radial flow, non-divided water box condenser; Muntz metal tubes and tube sheets.
2 Westinghouse Electric & Manufacturing Co. 16 in., 5850-g.p.m., 27.6 ft. head, 575-r.p.m. double-suction motor driven centrifugal circulating pumps.
2 Westinghouse 5 in. 270-g.p.m., 114 ft. head, 1160-r.p.m. double-suction motor driven centrifugal condensate pumps.
2—Westinghouse Compound Le Blanc steam jet air pumps complete with intercooler and after condenser. Jets operate at 300 lb. gage and require 720 lb. of steam per hour. Jet capacity is 105 lb. of 70 deg. F. free air per hour.

Condenser Performance

Steam Condensed Per Hour	No. of Pumps	g.p.m.	Absolute Back-Pressure, Inlet Temp.	in. Hg
125,000	2	11700	55° F.	1.21
100,000	2	11700	"	1.00
80,000	2	11700	"	.85
125,000	1	7300	"	1.81
100,000	1	7300	"	1.39
80,000	1	7300	"	1.14

Boilers and Boiler Equipment

3 Wickes Boiler Co. 880-hp. bent-tube boilers for operating pressure of 400 lb. Boilers have 8797-sq. ft. heating surface each and are capable of evaporating 80,000 lb. per hr. each.
3 Superheater Co. Elesco convection type superheaters designed for an average total temperature of 700 deg. F. at 400 lb. gage.
3 Sets Diamond Power Specialty Corp. Soot blowers.
3 4-in. Consolidated Ashcroft Hancock Co. safety valves per boiler.
1 Yarnall-Waring Co. water column with inclined Sesure gage per boiler.
2 3-in. Edward Valve & Mfg. Co. stop check valves per boiler.
1 1½-in. No. 741 and 1 1½-in. No. 743 Edward Valve & Mfg. Co. blowoff valves per boiler.
3 John V. Boland Construction Co. boiler settings using Walsh XX for first quality and Okilo for second quality refractory. Sifting, soot and fly ash hoppers lined with 2½-in. common brick.
3 Bigelow-Liptak Corp. front furnace walls suspended type, 8 ft. 6 in. high by 14 ft. 6 in. long. Effective refractory thickness 11½ in.
12 United Conveyors Corp. boiler inspection doors 9 in. by 12 in., air-tight type, 4 per boiler.
3 Combustion Engineering Corp. rear water walls each consisting of 29 plain 3¼ in. dia., 6 gage seamless steel tubes, effective length 11 ft., heating surface 145 sq. ft. Each water wall has 2 observation doors and an insulated steel casing.
3 American Engineering Co. 29MC6 eight-retort, 29-tuyere, power-ash-dump stokers, each having projected grate area of 182.6 sq. ft. and grid type air cooled front wall protection. Each stoker is driven by a 5-hp., 2-speed Louis Allis motor. Stokers will be fired with 1¼-in. Pittsburgh nut and slack having a dry B.t.u. value of 13,500. Ash fusing temperature is 2200 deg. F.
3 Louis Allis Co., 1200/600 adjustable delivery stoker drives complete with drums and contactors.

Coal and Ash Handling Equipment

Coal handling equipment consists of a belt elevator, belt conveyor over the coal bunkers and a tripper; designed and built by Michigan Limestone & Chemical Co.; capacity 200 t. an hr.
Merrick Scale Co. Weightometer.
6 Rolland Gardner & Co. Non-Seg coal spreaders, each 74 in wide.
6 Henry Pratt Co. 14 in. by 2 ft. 6 in. single under-cut type coal valves.
Coal bunker, Allied Engineers design, 3 @ approx. 125 t. each.
6 Beaumont Manufacturing Co. ash gates 5 ft. stroke by 5 ft. 6 in. wide, Roller Under-dry type with 9-in. oil operating cylinders suitable for 165 lb. oil pressure.
1 Beaumont Manufacturing Co. 2½ in. oil unit complete with 100-g.p.m., 165-lb. pressure motor-operated pump.
9 Beaumont ash quenchers.
6 W. S. Rockwell Co. hopper gates, 8 in. and 6—6 in. Kwikleen type.

Air Preheaters and Fans

3 Babcock and Wilcox Co. air preheaters, tubular type, each 4,555 sq. ft. heating surface.
3 American Blower Corp. induced draft fans, No. 8 double-inlet 2/3 double width, American Sirocco type, driven by 125 hp., 2-speed motors.

Performance

Cu. Ft. of Gas	Static Pressure	Temp.	r.p.m.
80,500	5.0	550° F.	690
50,000	3.1	535° F.	518
39,000	2.05	495° F.	409

3 American Blower Corp. forced draft fans, No. 7 double-inlet double width, American H. S. type, driven by 75 hp. 2-speed motors.

Performance

Cu. Ft. of Air	Static Pressure	Temp.	r.p.m.
34,500	7.0	70° F.	1150
26,500	3.9	70° F.	860
17,500	1.75	70° F.	575

Feedwater Heaters and Pumping Equipment

1 Alberger Heater Co. low pressure, 6-pass, 627 sq. ft. closed type feedwater heater heating 120,000 lb. of water per hour from 80 deg. F. to 178 deg. F. using 8.5 lb. absolute steam.
1 Alberger Heater Co. low pressure, 4-pass, 310 sq. ft. closed type feedwater heater heating 120,000 lb. of water per hour from 178 deg. F. to 227 deg. F. using 26 lb. absolute steam.
3 De Laval Steam Turbine Co., boiler feed pumps 2—300 g.p.m., 4-stage centrifugal, 1035 total head, 3500 r.p.m. motor driven; 1—300-g.p.m., 4-stage centrifugal, 1035 total head, 3500 r.p.m., driven by De Laval 350 lb. gage single-stage turbine.
2 Union Steam Pump Co. house service pumps, one 400 g.p.m. and one 600 g.p.m., 100 total head, motor driven.
1 American Steam Pump Co. fire pump, 4 in., 600 g.p.m. 2-stage, 230 ft. total head, 2200 r.p.m., driven by Terry ZS, 65-hp., 400-lb., 700 deg. F. turbine.
1 American Steam Pump Co. drip pump, 1-in. twin centrifugal pump and receiver set, motor driven.
1 Viking Pump Co., oil purifying pump, 2 in., 50 g.p.m., motor driven.
1 Nash Engineering Co. circulating pump primer, 1¼ in. Mod. P.B.S. Hytor, motor driven.
Water softener.....Permutit Co.
1—30 g.p.m. Zeolite softener; 1—32 g.p.m. filter; 1—Brine tank; 1—Phosphate tank.

Piping, Valves, Fittings

Piping
High and low pressure piping and fittings including a portion of the high and low-pressure valves.....Crane Co.
Expansion joints, copper....Jos Kopperman & Sons
Expansion joints, rubber.....United States Rubber Co.
Valves
Gate, globe and check—Walworth Co.
Motor operated gate.....The Chapman Valve Mfg. Co.
Stop check .....Lunkenheimer Co.
Non return .....Elliott Co.
Reducing ..The Mercon Regulator Co.
Boiler feedwater regulators 3 in. Copes RG with type R thermostat..Northern Equipment Co.
Regulator—water .....The Hoppes Mfg. Co.
Heater drainers.Atwood & Morrill Co.
Liquid level controllers.....Fisher Governor Co.
Float controllers.....Atwood & Morrill Co.
Traps—high pressure.....W. H. Nicholson & Co.
Traps—low pressure .....Strong, Carlisle & Hammond Co.
Traps—heating system .....Warren Webster & Co.
Steam separator, 8 in.....Strong, Carlisle & Hammond Co.
Desuperheater, 14-in. spray and cone type .....Elliott Co.
Strainers .....Elliott Co.

Instruments

Combustion Control ....Hagan Corp.
Gages, pressure indicating.....Crosby Steam Gage & Valve Co.
Temperature controller.....Consolidated Ashcroft Hancock Co., Inc.
Water gages .....Crane Co.
Gas analyzer.....The Hays Corp.
Recorders, indicators and clocks.....The Bristol Co.
Coal sampler.....Sturtevant Mill Co.
Thermometers, industrial type.....Precision Thermometer & Instrument Co.
Vacuum gage.....C. J. Tagliabue Mfg. Co.
Draft gages.....The Hays Corp.
Boiler feedwater meter.....
1—Type M Venturi register, indicator and recorder with 6 in. Style N.S. Venturi tube.....Builders Iron Foundry
Boiler meters.....Bailey Meter Co.

Other Equipment

Ducts, breechings, hoppers and generator air cooler housing.....Leitelt Iron Works
Stacks, suitable for refractory lining .....Leitelt Iron Works
8 Miscellaneous tanks.....Leitelt Iron Works
Pipe and platework insulation.....J. M. 85 Per Cent Magnesia and Superex .....Rankin-Dutney Corp.
Air compressor....Ingersoll-Rand Co.
Oil purifier, 150-600 g.p.m.....The Sharples Specialty Co.
Unit heaters, 7 units.....Carrier York Corp.
Electric motors.....General Electric Co.
.....Allis-Chalmers Mfg. Co.
.....Westinghouse E. & M. Co.
Switchboards....General Electric Co.
Electrical meters.General Electric Co.
Voltage regulator.....Westinghouse
Oil circuit breakers, type B-32.....Westinghouse
Concrete cell structure.....Designed by Allied Engineers, Inc.
Air circuit breakers with Weston Ammeters.....I.T.E. Circuit Breaker Co.
Relays, reactors, etc.....General Electric Co.
1 Link-Belt Co. intake screen for circulating water tunnel.
3 Allis-Chalmers Mfg. Co. single-phase, self-cooled transformers for station auxiliary service, each 500 kv-a., 13,800/460 v.
Lighting circuit transformers.....Allis-Chalmers Mfg. Co.
Storage battery, 125-v., NHSX-9.....Gould Storage Battery Co.
Diverter pole type battery charging generator set, 2 kw.....Rochester Electric Corp.
Turbine room crane, 50 t.....Northern Engineering Works

with the necessary boiler instruments. Draft gages show the operation of the fans and recording gages show temperature at various parts of the system. A steam-flow-air-flow boiler meter indicates and records the relations of steam and air flow for best combustion efficiency. All boilers are under the control of a combustion control system but each boiler may be manually operated if desired.

The plant building is of brick and steel construction with limestone trim. It is well lighted in the daytime by well-placed windows, and at night by carefully designed artificial illumination. The turbine room is finished in salt-glazed brick with a floor of red quarry tile. The rest of the interior is painted. Every reasonable effort has been made to promote cleanliness in the plant by sealing off coal bunker and leaving a totally enclosed passage for coal from bunker to hopper. Safety has also been kept in the foreground by design and placing of equipment for convenience and safety in operation and by the use of guards where necessary.

This power plant was designed for the Michigan Limestone and Chemical Co. by Allied Engineers, Inc., of which Geo. C. Daniels is chief mechanical engineer. It was built by Michigan Limestone Chemical Co. of which R. C. Stanbrook is power engineer. We are indebted to them for the most cordial coöperation in providing data used in this article.

Fixed Charges on Power Equipment

INTEREST, PROPER DEPRECIATION, TAXES AND INSURANCE ARE FACTORS. BY OTTOMAR H. HENSCHEL*

IN DETERMINATION of the cost of plant equipment operation, due consideration must be given to both fixed and operating charges or a true picture will not result.

Briefly stated, the fixed charges may be segregated as: (a) Interest, (b) depreciation, (c) taxes, (d) insurance.

Operating charges are divided into: (a) Material consumed, (b) attendance, (c), maintenance, (d) repairs.

INTEREST

Prevailing rates of interest tend to vary, not only according to the so-called value of money at any particular time but also according to the soundness and the nature of the investment involved. Rates may be from 2 per cent to 8 per cent. Stable government rates may be 2 or 3 per cent; those of large industrial projects may be 5 or 6 per cent while rates of interest paid by the smaller industrials and individuals are liable to reach a maximum of 8 per cent and even in some instances 10 per cent.

Ordinarily, however, in determining fixed charges the item of interest may be taken at 5, 6 or 7 per cent. Conservatively a rate of 6 per cent can be accepted.

DEPRECIATION

As a unit becomes older its value decreases; it depreciates. In order to maintain a fixed capital value, it is customary in proper accounting practice each year to "depreciate" the unit or machine some given amount and set up a depreciation reserve. Naturally, the rate of depreciation varies, inversely proportional to the anticipated length of life of the equipment under consideration. If L be the anticipated length of useful life and R the rate of depreciation in per cent, the value of R will be:

$$R = 100 \div L$$

For a life of 25 yr. the rate of depreciation should then be $R = 100 \div 25 = 4$ per cent. In other words, each year an amount equal to 4 per cent of the original value of the equipment, should be put into the depreciation reserve until at the end of 25 yr., the total depreciation reserve would be equal to the original cost.

TABLE I. LIFE AND DEPRECIATION FOR POWER EQUIPMENT

Unit	Assumed Life Years (A)	Yearly Depreciation, Per Cent Commonly Accepted (B)	Correctly Determined (C)
Boilers - fire tube	16	6.67	3.89
Boilers - water tube	20	5.00	2.71
Breechings and connections	10 to 25	4.00 to 10.00	7.59 to 1.82
Buildings - brick and concrete	50	2.00	0.35
Buildings - wooden	50	2.00	0.35
Cables - underground lead covered	25	4.00	1.82
Cables - aerial lead covered	16	6.67	3.89
Coal and ash handling equipment	20	5.00	2.71
Condensers	25	4.00	1.82
Conduits	50	2.00	0.35
Electrical auxiliaries	10	10.00	7.59
Engines - steam low speed	20	5.00	2.71
Engines - steam high speed	16	6.67	3.89
Engines - gas	16	6.67	3.89
Feed water heaters	30	3.33	1.26
Feeders - weatherproof insulation	16	6.67	3.89
Fencing - steel	20	5.00	2.71
Foundations	Life same as supported machinery		
Fuel oil handling equipment	25	4.00	1.82
Generators - modern	20	5.00	2.71
Generators - obsolete	16	6.67	3.87
Generators - steam turbo	10	10.00	7.59
Meters - electric switchboard	20	5.00	2.71
Meters - electric service	16	6.67	3.89
Piping and covering	25	4.00	1.82
Pumps - steam	20	5.00	2.71
Stack - brick	50	2.00	0.35
Stack - steel	10	10.00	7.59
Steel - structures	25	4.00	1.82
Stokers - fixed parts	20	5.00	2.71
Stokers - moving parts	5	20.00	17.74
Storage batteries	16	6.67	3.89
Switchboard and wiring	20	5.00	2.71
Telephones	10	10.00	7.59
Transformers - station service	16	6.67	3.89
Turbines - steam	20	5.00	2.71
Turbines - water	16	6.67	3.89

In Table I are presented values representing accepted anticipated length of life of various pieces of power plant equipment, with corresponding commonly accepted rates of depreciation, Column B.

Virtually, however, the above method as commonly employed is incorrect. The primary object of setting up a depreciation reserve is to maintain a constant value of capital account. Obviously, when a year's depreciation is set aside, it should at once draw interest so that, as the depreciation reserve increases in value, the accrued interest also would increase, with the result that, at the end of the anticipated life of the unit or machine, there will be on hand, not only its original value but also the accrued interest.

Consider a unit with value of $1,000, a life of 10 yr., a scrap value at the end of 10 yr. of $100 and with a prevailing interest rate of 6 per cent. We can

*Consulting Engineer, Milwaukee, Wis.

then set up the following depreciation reserve, when employing a straight rate of 10 per cent depreciation.

End of Year	Amount Set Aside	Value with Accrued Interest
1st	$100	$100.00
2nd	100	206.00
3rd	100	318.36
4th	100	437.64
5th	100	563.86
6th	100	697.64
7th	100	839.46
8th	100	989.80
9th	100	1,149.14
10th	100	1,318.08

At the end of the tenth year the machine is unfit for further service but is scrapped for $100. The capital in hand will be $1318.08 plus $100 = $1418.08 or $418.08 in excess of the original cost of the unit. Because of this factor of compound interest it appears incorrect to use the common formula, $R = 100 \div L$ in determining the per cent of depreciation.

Development of the proper rate of depreciation to be employed is complicated, involves lengthy mathematical processes and would require no little time in the derivation of rates for various values of anticipated life of unit, or machine, and rate of interest. Such rates of depreciation are, however, given in Table II as presented by O. B. Goodman in his treatise on the subject of Financial Engineering. Referring to this table, with an anticipated life of 10 yr. and with an interest rate of 6 per cent, compounded, a depreciation rate of 7.587 per cent yearly should be used instead of 10 per cent.

Depreciation rates given in Column C, Table I, are based upon an interest rate of 6 per cent and for life and depreciation rates as presented in Table II.

Plant Operation

In cost determinations, the item of depreciation appears as of the plant rather than as of the component parts of the whole. Accordingly, then, in order to arrive at a proper rate of plant depreciation each of the units should first be considered individually. For a small combined electric generating and refrigerating steam-operated installation we would have:

Item	Cost	Yearly Depreciation Rate	Yearly Depreciation Amount
Buildings—brick	$30,000	0.35	$ 105.00
Boilers—fire tube	15,000	3.89	583.50
Pumps, auxiliaries and piping	3,300	2.71	89.43
Stack, brick	5,000	0.35	17.50
Feedwater heater and piping	1,500	1.26	18.90
Stokers—moving parts	4,000	17.74	709.60
Stokers—stationary parts	2,000	2.71	54.20
Slow speed engine	12,000	2.71	325.20
Generators	6,000	2.71	162.60
Switchboard and wiring	3,600	2.71	97.56
Refrigerating unit	9,000	2.71	243.90
Total	$91,400		$2407.39

Thus we have a total plant investment of $91,400 and a yearly depreciation amounting to $2407.39. The mean depreciation rate is evidently the net depreciation amount divided by the total cost or, $2407.39 divided by $91.400, or, 0.0263 or 2.63 per cent.

Ordinarily one might accept 8 per cent as a fair rate of depreciation of a power plant. With the investment of $91,400 this would be equal to $7312 while in reality the amount charged to depreciation should be but $2407.39. Naturally a single point of this kind is of vital importance in plant operation cost data, particularly where comparison is to be made between costs of locally generated and of purchased power.

Let us now consider an actual case in which electric energy is being purchased through the medium of an out-of-door type of substation erected by the consumer. The original unit consists of two 200-kv-a., 26,400-v. to 220/440-v., single-phase transformers connected open

TABLE II. DEPRECIATION RATES FOR VARIOUS LIFE AND COMPOUND INTEREST RATES. O. B. GOLDMAN.

Life	Interest Rate							
	0.03	0.04	0.05	0.06	0.07	0.08	0.09	0.10
1	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000
2	49.261	49.020	48.780	48.544	48.309	48.077	47.847	47.619
3	32.353	32.036	31.722	31.410	31.106	30.804	30.505	30.211
4	23.902	23.563	23.203	22.859	22.523	22.192	21.867	21.547
5	18.836	18.471	18.099	17.739	17.389	17.046	16.701	16.380
6	15.460	15.082	14.703	14.336	13.980	13.632	13.292	12.961
7	13.051	12.665	12.305	11.913	11.553	11.207	10.869	10.541
8	11.244	10.856	10.473	10.104	9.747	9.402	9.068	8.744
9	9.843	9.452	9.070	8.702	7.879	8.008	7.680	7.364
10	8.724	8.331	7.951	7.587	7.238	6.903	6.582	6.278
11	7.808	7.417	7.039	6.679	6.335	6.007	5.695	5.398
12	7.046	6.657	6.283	5.928	5.590	5.269	4.965	4.678
13	6.405	6.016	5.646	5.296	4.965	4.652	4.357	4.078
14	5.853	5.458	5.103	4.759	4.434	4.130	3.844	3.575
15	5.376	4.995	4.634	4.296	3.979	3.683	3.408	3.147
16	4.961	4.583	4.229	3.895	3.586	3.298	3.030	2.782
18	4.271	3.900	3.555	3.236	2.941	2.670	2.421	2.193
20	3.722	3.358	3.024	2.718	2.439	2.185	1.955	1.746
25	2.743	2.401	2.095	1.823	1.581	1.368	1.181	1.017
30	2.102	1.783	1.505	1.265	1.059	0.883	0.734	0.608
35	1.654	1.358	1.107	0.897	0.723	0.580	0.464	0.369
40	1.326	1.052	0.828	0.646	0.501	0.386	0.296	0.226
50	0.887	0.655	0.478	0.347	0.246	0.174	0.123	0.108
60	0.613	0.420	0.283	0.188	0.123	0.080	0.051	0.033
75	0.367	0.223	0.132	0.077	0.044	0.025	0.014	0.008
100	0.165	0.081	0.038	0.017	0.008	0.004	0.002	0.001

delta, together with steel structure, insulation, wiring, air-break switches, lightning arresters, concrete flooring, fencing, and costing complete with labor of erection $4674.45.

If, as usual, we accept a flat rate of 8 per cent, the annual depreciation charge would be equal to $373.96.

Determination of this depreciation charge by the more approved method would give:

Item	Cost	Per Cent Rate of Depreciation	Depreciation Charge
Steel structure	$ 750.00	1.82	$ 13.65
Air break switches, fuses insulators, choke coils, wiring etc.	384.70	7.59	29.22
200 kv. a., 26,400 to 220/440 v. single phase outdoor type of transformer	1724.00	3.89	67.06
Pellett type of lighting arresters	225.75	7.59	17.15
Fencing	490.00	2.71	13.28
Concrete work	600.00	0.35	2.10
Labor, depr. in 20 yr	500.00	2.71	13.55
Total	$4674.45		$156.01

Then, as in the case of the steam generating plant cited, the mean rate of depreciation will be equal to $156.01 divided by $4674.45 or, 3.34 per cent.

Taxes and Insurance

Taxes vary to a great extent dependent upon locality. In general, the variation may be from less than 0.5 per cent to over 2 per cent.

Various types of insurance may be required in connection with power plant operation. These are in the main: (a) Fire, (b) boiler, (c) flywheel, (d) compensation. The rate is bound to be variable and is ordinarily based upon a percentage of the capital invested in plant, or the original cost of the plant. Whenever fixed charges are to be determined, it is recommended that the annual premium paid for each of the above or other classes of insurance applicable to the plant proper be secured from the accounting department and these values used instead of attempting to use some fixed percentage of the whole.

Naturally, the item of compensation insurance is based upon the value of the payroll and that portion applicable to the power plant can be prorated accordingly.

Selecting Boiler Plant Equipment Intelligently

John Van Brunt, Vice-President in Charge of Engineering, Combustion Engineering Corp.
Tells Members of the T. A. P. P. I. the Detailed Steps in the Selection of Steam Pressure and Steam Generating Equipment for Use in the Industrial Plant.

EACH MILL has its own particular problem and the correct selection of pressure and equipment can be made only after an analysis by a steam engineer thoroughly familiar with the requirements of that mill, but for plants having no hydroelectric power the problem of the selection of steam plant pressure may be simply stated as follows: Select such a steam pressure and temperature that the total amount of steam used in the process for cooking, drying and heating will generate, in a back pressure or bleeder turbine between the initial pressure and the pressure required for process, the entire power required by the mill.

If this can be done, the plant is perfectly balanced, no heat is wasted to the condenser and no power generated beyond mill requirements. If the power required is more than can be generated by the process, condensing steam turbines may be used and the steam for process bled at one or more stages of the turbine or a straight condensing turbine of sufficient capacity may be used in addition to the back pressure units. When this analysis is completed and the proper pressure and temperature determined, there remains the selection of the type of boiler and furnace and firing equipment.

Assume that a pressure of 600 lb. gage, 700 deg. F. will fulfill the heat balance requirements; what kind or type of boiler shall be used, how many units, how fired, at what rate of evaporation shall the boilers be operated, shall economizers or air heaters or both be used? These are questions which must be answered before the design of the plant can be carried through, but will be simplified somewhat by the engineers' analysis which, in addition to the steam pressure and temperature, will provide essential data such as the maximum steam and kilowatt demand, duration of peak, load factor, amount of condensate returned to the boiler, makeup water, analysis of water, all of which when properly weighed will aid in the solution of the problem.

Selection of a method and equipment for burning coal available is more important and should be made prior to the choice of boilers. For this reason the study of the coals available must be thorough. It is generally understood that some coals may be satisfactorily burned on stokers of a certain type and certain other coals on stokers of another type. It is not so generally realized that no stoker will handle with equal facility many different kinds of coal. Practically all bituminous coals may be burned equally well in pulverized form but not at the same rates of combustion in any given furnace.

If it is found that several kinds of coal are available, consideration must be given to the quality of each, the probable amount of each that will be used and the burning characteristics of each on stokers or in pulverized form. If all coal available is of such quality that it can be burned on stokers, then stokers should receive careful consideration. On the other hand, if the quality and ash melting point varies and is low, burning in pulverized form is preferable. The cost of the coal will determine whether a low cost moderate efficiency or a high cost high efficiency plant is most economical.

Having decided how the coal available may be burned to best advantage, the type of furnace and range of combustion rates should be fixed. In the burning of pulverized coal in wholly or partly water cooled furnaces, the relations of combustion rate, volume of furnace area of water-cooled walls, combustion air temperature, melting temperature of ash, location of boiler tubes in relation to burners and spacing of boiler tubes, to boiler availability or hours of continuous operation are little understood or appreciated by the average purchaser of boiler plant equipment. High combustion rates of low or medium fusion temperature ash coal results in rapid destruction of furnace walls. Low combustion rates with good coal are permissible in refractory furnaces.

Average coal having an ash fusion temperature of 2100 to 2500 deg. should be burned in water-cooled furnaces and the combustion rate should be so proportioned that the temperature of gas entering the first bank of boiler tubes will be lower than the ash fusion temperature for continuous operation. For short swings, the temperature may be higher, depending on the duration of the swings.

For example, while it may be possible to operate

at 25,000 B.t.u. per cu. ft. for one hour and 23,000 for three hours, any attempt to go beyond 18,000 B.t.u. for continuous operation twenty-four hours a day for thirty days would result in fouling of the gas passes of the boiler and building up of clinker in the bottom of the furnace.

A few years ago advocates of high heat release furnaces predicted rates of 50,000 to 100,000 B.t.u. per cu. ft. True, coal may be nearly completely burned at such rates provided it is very finely pulverized. Today, however, experience has demonstrated that such rates are impractical. Excessive slagging of boiler tubes, combustible losses and high cost of pulverizing have placed fairly definite limits on practical combustion rates.

The value of continuous service or availability should be weighed. The desired reliability may be obtained by designing for continuous service or by providing spare capacity in an additional boiler so that a regular schedule of outage may be established for all necessary cleaning and repairs.

Knowing the kind of coal to be used, the amount, pressure and temperature of steam and having determined the method of firing, the combustion rate and size of furnace, the engineer is now in a position to proceed with the selection of the boiler and the number of units required.

If the boiler must fit into an existing boiler room or between existing columns and beneath existing girders, the choice is narrowed as is the case if the space available is otherwise limited. If a new building is contemplated, the boilers may be as large as may seem desirable and the number of units may be reduced to a minimum.

With the number of units known and the furnace volume determined from the combustion rate, an approximation of the furnace width may follow. A very narrow boiler may not be suitable as in order to obtain the required volume in furnace, the height of furnace or depth from front to back or both may be too great to obtain a correctly shaped furnace. For example, if 10,000 cu. ft. are required, a boiler 20 ft. wide with furnace 25 ft. high and 20 ft. deep would be well proportioned while a furnace 12 ft. wide would be 30 ft. high and 28 ft. deep, absurdly ill proportioned. Also, in a boiler and furnace too narrow, the draft loss will be too high.

There are two major types of boilers suitable for 600-lb. pressure units—a straight tube or sectional header boiler and the bent tube type, the latter being made in two, three, and four drums design. Any of these boilers can be designed for any desired pressure. The factors determining the selection are (not necessarily in order of importance): first cost; space occupied; space necessary for renewal of tubes; space in which boiler must be located; whether economizers or air preheaters are to be used; space occupied by economizers or air preheaters. In the range of pressures from 500 to 650 lb., straight tube boilers will usually cost less as riveted drums may be used, whereas the bent tube boiler will require forged drums.

Frequently, it is desired to extend an existing boiler room to utilize existing coal handling apparatus. The space then available may be a deciding factor in the type of boiler. For example, extending a coal bunker may so block the aisle in front of the boiler that there will be no room to remove tubes from a sectional header boiler. It may not be possible to remove them from the rear, particularly if an economizer or air heater must be placed in the rear. A bent tube boiler will often meet that condition and in addition the space between the inclined tubes and the front wall will add materially to the volume of the furnace.

Boilers of either type operated at over 100,000 B.t.u. per square ft. of heating surface will have exit gas temperature 200 deg. to 250 deg. above saturated steam temperatures. Hence fuel economy will dictate the installation of an economizer and or air heater following the boilers. For exit gas temperatures up to 700 deg. or 750 deg., an air preheater will reduce the gas to about 350 deg. and preheat combustion air to 550 or 600 deg. For stoker fired units, this temperature is too high, therefore the air heater should be preceded by an economizer or the economizer only should be used. Also, in direct fired pulverized coal firing, an air temperature of 550 or 600 deg. is under most conditions higher than desirable.

On indirect fired units, an air temperature of 300 to 350 deg. will be found sufficiently high for mill drying. Higher temperature than this will necessitate excessive tempering. With an air preheater it is possible to bring the flue gas down to 200 deg. but with few exceptions such a low temperature is not desirable as condensation may occur at temperatures of 300 deg. F. or even higher.

To summarize: first determine the coal or coals to be used, then the method of firing, the combustion rate, the grate surface or furnace volume, next the furnace width and size of boiler, the rate of driving, the type of boiler and the nature of the extended surface, that is, economizer or air heater.

Studies of two or more equally satisfactory arrangements will usually be sufficient to determine the most economical, if at the same time proper weight is given to accessibility for operators and repairs and labor required for routine operation.

Only by intimate knowledge of all of the factors and by the exercise of a sound and well-balanced judgment will a correct solution be reached.

In the Montague Water Conservation District of California is a 250-hp. motor-driven, direct-connected centrifugal pump at the Big Springs pumping plant. To prevent the water in the discharge line from reversing the pump if power fails, a check valve was installed on the discharge side of the pump. This valve, however, caused an appreciable drop in pumping efficiency because of excess friction and another method of accomplishing this result was sought.

A General Electric Thrustor or electro-hydraulic operator, driving a magnetic brake rated at 2000 lb., was finally installed. This holds the pump stationary in the event of power failure and lets the water in the pipe line flow out gradually with no surge disturbance. The size of the brake was determined by trying to hold the pump with the check valve open, just at the instant of reversal, by throwing on the motor. Knowing the motor torque under such conditions, the size of the brake was estimated.

Automatic Burning of Fuel Oil

PROPERTIES OF FUEL OILS, PREHEATING REQUIREMENTS, PIPING AND OIL CONTROL EQUIPMENT FOR HEATING BOILERS. BY C. C. CUSTER*

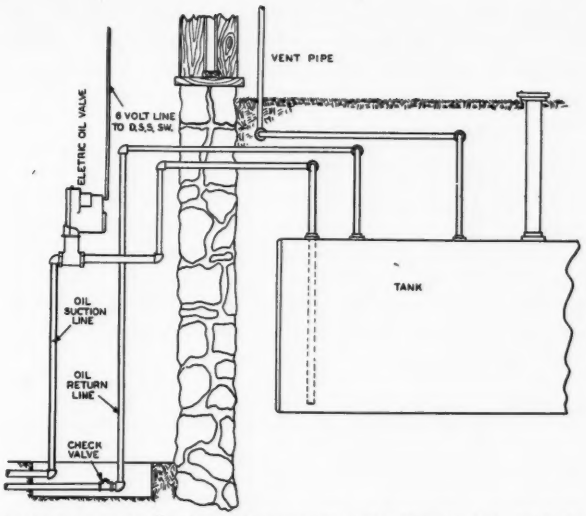
SOMEBODY has truly said that "this is a changing world." The platform orator loves to dwell on the Stone Age, the Bronze Age, the Iron Age, the Age of Steel, of Electricity and Steam Power, of Power and More Power. There is a filling station going up on the next corner, my small boy in kindergarten is being taught to look both ways before he crosses the street. My older boy in high school is studying the theory of combustion engines, and I imagine this might be called the "Age of Hydrocarbons" or "Portable Power." The production and use of petroleum products has increased by leaps and bounds. Besides the use to grease the wheels of our machinery and to propel our autos and aeroplanes, it is beginning to compete with coal to heat our buildings.

Hydrocarbons are the principal elements in some of the most useful servants of mankind, such as sugar, alcohol, gas, gasoline, naphtha, kerosene, turpentine. All these hydrocarbons, however, are highly inflammable, especially in certain forms, and may be explosive and quite dangerous in other forms. So it behooves everybody to understand his hydrocarbons.

HAZARDS TO BE WATCHED

Hazards do not always mean serious danger. Some classes of hazards need but to be known to be easily avoided, or to be cured by inexpensive precautions. Other precautions necessary may be more expensive but may be considered as being highly advisable in view of the fact that we thus avoid future trouble and expense. Oils are dangerous in proportion to their so-called flash point. The flash point relates to the temperature and pressure where the particular oil goes into its gaseous state. This point of flash also closely follows the Baumé density of the oil provided it is not a compounded oil—that is—provided it is a purely distilled oil of even density. After the flash point is passed and still more heat is added, we come to the "fire point" or where the whole mass continuously gasifies and goes up in flames more or less violently.

In watching the processes going on in an oil refinery, we note that as the crude oil is heated in an enclosed retort there are certain gases evolved that



TANK PIPING SHOWING USE OF ELECTRIC OIL VALVE WHEN TANK IS INSTALLED ABOVE LEVEL OF BURNER

are in temperature beyond their fire point evinced by the fact that where there is a small leak in the pipe line carrying them the escaping gas immediately ignites on striking the air. This is what some would call spontaneous combustion. In reclaiming such hydrocarbons, it is merely necessary to pass them through a cooling coil or condenser to liquefy them. Hydrocarbon gases are always lurking dangers because whenever they get mixed with about nine times their bulk of air they burn instantaneously with a destructive explosion. This is why a so-called empty oil drum is sometimes more dangerous than one that is full. If it were full, you could only set it on fire but if it contains lurking gases mixed with air, you might be badly damaged by the resulting explosion.

CLASSIFICATION OF FUEL OILS

Fuel oils may be divided into two classes—distillates and residuals. Distillates comprise the oils of 26 gravity Baumé and above which may be distilled "over the top" and separated into various grades up to 40—42 Baumé. Beyond 42 comes kerosene which is too valuable for other purposes to be used for fuel. The product at 50—52 Baumé is called naphtha commercially. The ordinary gasoline as used in cars is of 60—62 gravity Baumé. Winter gas may be as high as 70 Baumé. The higher the Baumé gravity of oils the more dangerous they are and the greater precautions are necessary in the handling. The law in many of our larger cities prohibits the use of oils for fuel if the flash point is below 130 deg. F.

Residuals are the oils below 26 Baumé down to as low as 12—14 Baumé. These are too heavy to be distilled "over the top" and must be purified by filtration and other processes. The crude oils of asphaltum base are the best producers of good quality heavy fuel oils. The heavier paraffine base crude oils produce fuel oils which are not of proper viscosity to flow well through pipes and burners. Not all oil burning apparatus is designed or intended to use both the residual and distillate oils.

Trade names for these fuel oils run something like the following: Fuel oil No. 1 Distillate—38 to 42

*Safety Engineer,

Baumé. No. 2 fuel oil is 32 to 36 Baumé. Fuel oil No. 3 is 28 to 32 Baumé, and the residuals are called Bunker A, Bunker B and Bunker C, which runs down to as low as 12—14 Baumé. The price ranges from about 4 cents or less to 9 cents per gal. At a price of 4 cents per gal. the Bunker C oil is a satisfactory fuel for driving ships as the hollow side and bottom tanks of the modern steel ship can be used to store sufficient fuel oil to last the ship for a round trip with an increased steaming radius over the same ship using bunker coal as well as economizing the available capacity of the ship for storing cargo. These Bunker oils are probably so named on account of their popular use on ships.

TABLE I. PROPERTIES OF FUEL OIL AT 60 DEG. F.

Baume' Gravity		Specific Gravity	Weight Lb. per Gal.	B.t.u. per lb.	B.t.u. per Gal.	B.t.u. Decrease per gal. per cent
10	Bunker C	1.0000	8.33	18,280	152,272	.0
12		.9859	8.21	18,400	151,064	.8
15	Bunker B	.9655	8.04	18,580	149,383	1.1
18		.9459	7.88	18,760	147,828	1.1
20	Bunker A	.9333	7.78	18,880	146,886	.8
24		.9090	7.57	19,120	144,738	1.5
28	Fuel No. 3	.8852	7.40	19,360	143,264	1.6
32	Fuel No. 2	.8612	7.21	19,600	141,316	1.5
36		.8372	7.01	19,840	139,078	1.6
40	Fuel No. 1	.8132	6.86	20,080	137,748	1.5

Note: The B.t.u. decrease shown is the per cent difference between the heat unit contents per gal. of each gravity shown.

At a price range of 4 to 9 cents for the oils tabulated in Table I, it can be shown that the lightest oil costs approximately 90 per cent more than the heaviest oil, which contains 8½ per cent more fuel value. It may be stated as a general proposition the lighter the gravity of the oil the more heat units per pound it contains, but it also must be remembered that oil is sold not by the pound but by the gallon. Consequently the lighter oil has less pounds per gallon than the heavier oils and is more expensive as fuel. In general the lighter oils are used for domestic heating where a free flow is necessary under automatic control devices. When Bunker C oil is used on shipboard it must be under manual control or at least manual supervision. In extreme cold weather like passing "round the Horn" it is likely to get so cold and stiff in the bunkers that the cargo pump will not draw, which necessitates preheating it up to 170 deg. F. so it may be pumped readily. This is done by having a steam heating coil or radiator located in the bunker tank close to the pump suction. After passing the pump the oil is further heated on its way to the burners by a closed type heater using steam pressure to get the degree of heating wanted to prepare it for being burned.

It will be noted by Table II that fuel oil of 30 Baumé or above needs no particular preheating before passing through the burners, in order to get it to atomize properly and to burn economically without a sooty flame. There are several ways to atomize fuel oils. The lighter grades are sometimes atomized by a centrifugal device which reduces the oil to a mist and mixes it with air but the medium and the heavier grades are generally fed into the burner under pressure by a pump. Sometimes steam atomization is used successfully but this method is not supposed to be so economical. In preheating and atomizing heavy Bunker oils, if too much heat or too high a temperature is used, it has a tendency to "crack" the oil and produce a carbon residue that will stop up the burner. Also sometimes small pockets of water will lie in the stiff oil and be drawn over by the pump, and this watery vapor coming through will extinguish the flame, which will need to be relighted by hand. Sometimes when a poorly refined lot of oil is being used, all hands will be kept busy cleaning and relighting burners. Considerable fire hazards exist on board ship when fuel oil is used and there are many precautions used and required by the Underwriters. The pipe from the supply to the pump must have a valve in it with fork handle which may be closed from on deck in case the oil piping breaks and oil catches on fire. Water thrown on an oil blaze does little good in putting it out. A box of sand is placed in the boiler room to be thrown on incipient oil blazes. All cargo holds are fitted with steam pipes with open ends so that steam may be turned in to smother out oil fires. In spite of which now and then the use of fuel oil occasionally results in a ship being gutted by fire when on voyage. It is always customary to keep all bilges well cleaned and pumped out of oil so as to prevent spread of fire in case of an accidental blaze getting started.

Many precautions must be observed in the use of fuel oils for domestic and factory purposes. Both underwriters' rules for fire prevention and local and state laws must be followed. In the earlier days of use of oil-burning devices, many hazards were discovered and many safety devices have been perfected to cope with these hazards. To the person contemplating the installation of an oil-burning heating equipment, we would warn him against the use of too cheap apparatus as there should be sufficient money spent to get all the necessary safeguards that will make the operation at least reasonably safe.

TABLE II. FUEL OIL PREHEATING TEMPERATURES

Fuel Oil of low gravity requires pre-heating in order to permit complete mechanical atomization and the following table has been compiled giving the minimum temperature in deg. F. at which Fuel Oil will atomize at an approximate efficiency of 100 per cent.

Baume' Gravity	Temperature Deg. F.	Baume' Gravity	Temperature Deg. F.
10	300	24	140
12	280	28	90
15	250	32	70
18	220	36	55
20	180	40	40

Oil Burning Equipment

A satisfactory oil-burning equipment consists primarily of the following parts: (a) an adequate storage tank for oil, (b) an auto-motor driven pump and oil burner, (c) a proper ignition system, (d) proper furnace and stack conditions, (e) a coördinated system of automatic controls operating in conjunction with thermostat and safeguarding against any abnormal operating condition.

The tank should be of adequate capacity to buy oil at advantageous prices. The tank is best located out of doors and underground and may range in

capacity from 300 to 1000 gal. Some city ordinances require furnace oils to be stored on a level below the burner, and below frost line. A filling pipe 4 in. in diameter must terminate outside of building and be provided with sidewalk box and locked cover applicable for oil hose from railroad car or tank wagon. A vent pipe 1½ in. in diameter must be carried to 12 ft. above filling and 3 ft. from any building opening and provided at top with return elbow covered with No. 40 non-corrosive wire mesh screen. The suction pipe should be as short as possible in direct line, full size up to the burner. A return pipe is usually needed from the relief valve on the burner to the tank with no valves between. Pipe joints should have a perfect thread screwed up with litharge and glycerine. Run pipes sloping toward tank to avoid gas pockets. Where the tank is above the burner, install approved anti-siphoning valve or auto-electric cutoff valve. Figure 1 shows an approved piping diagram of a tank.

Many types of automatic oil burners are manufactured and we do not care to discuss their respective merits but for accident preventive purposes most city ordinances require by law safeguards against flooding and possibilities of explosion.

It is important that the chimney be of ample size and in good condition. It should have no other outlets or inlets and be continuous and be used only for the one boiler. The size of cross-section of chimney should suit the grate diameter and capacity of the boiler about as follows:

Grate Diameter	Minimum Inside Flue Dimensions inches
Up to 20 in.	8 by 8
21 in. to 27 in.	8 by 12
28 in. to 33 in.	12 by 12
5-6 Section 29-in. Boiler	12 by 16
7-8 Section 29-in. Boiler	16 by 16
9-10 Section 29-in. Boiler	16 by 20
11-12 Section 29-in. Boiler	20 by 20

Dampers which may entirely close the chimney uptake are prohibited, therefore, they must be removed entirely or securely fastened in the open position. In marine work it is found that the best condition of combustion is secured by first turning on the air till the stack gases become invisible, then cutting back the air till a slight haze is observed at the stack.

Use of well-placed refractory lining in the combustion chamber is important both to prevent the adjacent parts of the boiler from being overheated and to increase the efficiency of the flame. Radiant heat from the flame is reflected by the refractory lining again to the center of the oil flame to intensify the heat and to provide a more rapid gasifying of the oil vapor. The result is a better combustion and a quiet flame.

Ignition systems for oil-burning devices may be classified as (a) gas pilot ignition which is used when gas is available, (b) constant electric ignition or (c) intermittent electrical ignition. In the writer's opinion probably the best device is a combination of the gas pilot with auxiliary electric ignition.

Through the efforts and inventions of more than 50 American manufacturers of oil-burning devices

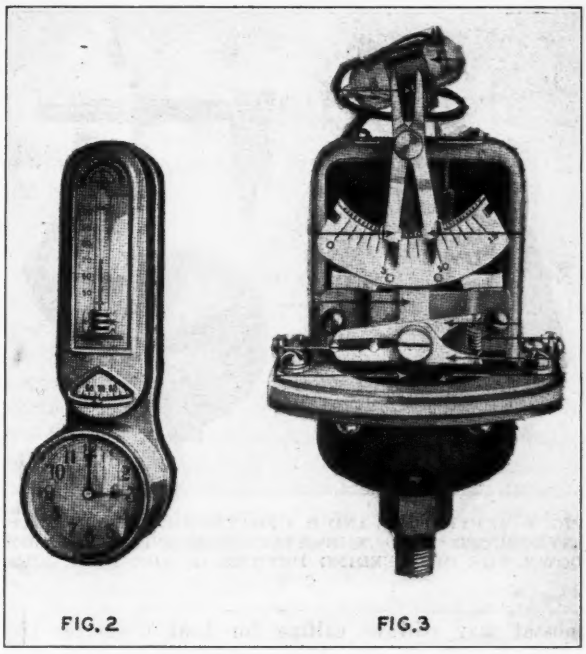


FIG. 2. THERMOSTAT WITH CLOCK TO CONTROL HEAT ACCORDING TO NEEDS OF THE HOUR
FIG. 3. PRESSURE CONTROLLER

there are today many examples of highly automatic operation of heating systems. For example, the primary control used is a thermostat, Fig. 1, which is located preferably in some central point in the building. This thermostat may or may not have in conjunction with it a clock which will automatically lower the temperature of the building a predetermined amount during the sleeping or occupied hours. When the thermostat calls for heat a relay circuit is closed which starts the electric motor driving the pump and burner. We will assume for purpose of description in this case that the safety devices also consist of a pressure control, Fig. 2, a protectostat, Fig. 3, or, what is equivalent, a device called variously a pyrotherm, pyrostat, or stack-switch, Fig. 4. A protecto-relay, Fig. 5, and may also consist of a further refinement shown in Fig. 6, a low-water cutoff.

The pressure control, Fig. 3, is merely a device for limiting the boiler pressure to a predetermined amount which may be 10 or 15 lb. The boiler may be said to be under dual control as, although the ther-

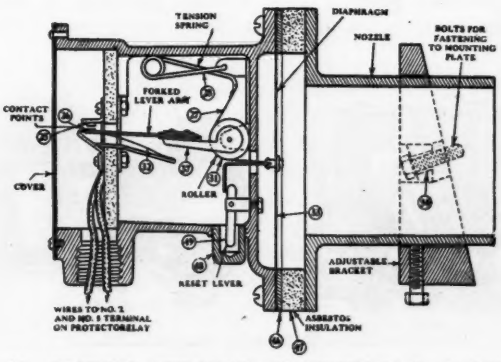


FIG. 4. SECTION THROUGH PROTECTOSTAT SHOWING WORKING PARTS

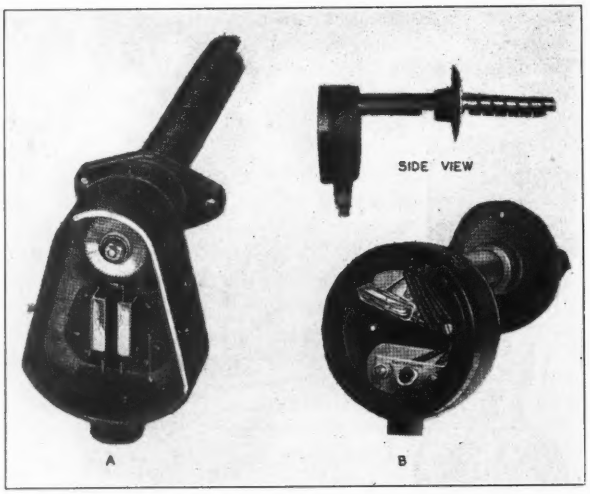


FIG. 5. A. PYROSTAT AND B. PYRATHERM, INSTRUMENTS INTRODUCED INTO THE STACK DESIGNED TO SHUT DOWN THE OIL FEEDING DEVICES IF THE FIRE GOES OUT

mostat may still be calling for heat whenever the boiler pressure reaches its maximum, the pressure control will prohibit any further forcing of the boiler till the pressure drops.

The protectostat is a simple mechanical device consisting of a housing and diaphragm securely fastened together. These are of similar metals having the same coefficient of expansion; therefore, they retain their relative position no matter to what temperature they may be subjected. If, however, the diaphragm is subjected to a higher temperature than the housing, it will tend to expand more rapidly and as it is held solidly at the circumference it will buckle in a direction towards which tension is applied by the contact mechanism. In operation the housing and the diaphragm remain at the same temperature until flame occurs, when the diaphragm being exposed to the radiant energy, or heat, from the flame, attains a higher temperature than that of the housing, and buckles inwardly.

Whenever the fire goes out and the protectostat is deprived of the radiant energy, the diaphragm gets on its inner side, and a contact is shortly after completed which shuts the burner down. Or this same function may be delegated to a pyrotherm, pyrostat, or stack switch which is controlled by the temperature of the stack gases. These devices function by means of the contraction of a heating element in the stack which either opens a relay contact circuit or tilts a Mercoid switch, either of which shuts down the motor operating the burner and oil pump.

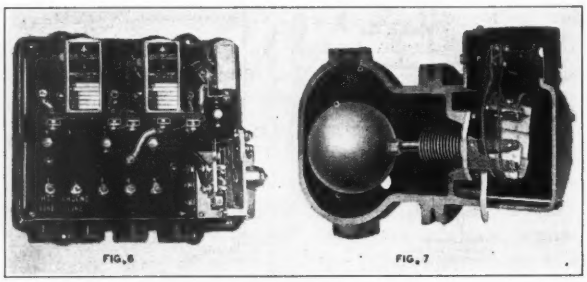


FIG. 6. PROTECTORELAY
FIG. 7. LOW WATER CUTOFF

The protecto-relay, Fig. 5, is a coördinated system of control by relays which may be explained as follows:

The protecto-relay is designed for the intermittent flame type burner, having ignition; burner motor and oil supply brought on simultaneously.

Ignition will normally continue until the protectostat or pyrostat is actuated by the flame. The maximum ignition interval is determined by the setting of the thermal safety switch. Standard timings for the thermal safety switch are 60, 90, and 120 sec.

Should the oil fail to ignite, or should the flame be prematurely extinguished due to water in the oil, lack of oil or other causes, the burner will go off safety. It will then be necessary manually to depress the thermal safety switch button, and release it before the burner can start again.

Should current service fail, even though momentarily, the control will completely recycle as soon as current service is resumed.

The burner used as an example employs both electric spark and gas ignition.

It will thus be noted that in this we have a safety device that not only takes care of the ordinary emergencies but also in case of something else wrong with the system out of its control will automatically shut down the system and wait till the owner renders service in the way of removing the trouble.

Inasmuch as there have been many cases of cast-iron sectional boilers burned up by failure of the returns to come back properly, it is often found desirable to install a low-water cutoff in the water column. This is shown in Fig. 7. As the float ball drops, it will be noted that it tilts a Mercoid switch that shuts down the motor driving the oil burner.

As is always the case with all automatic devices, in order to secure continuous and satisfactory performance, these devices should be periodically and frequently inspected and tested out to see that they are functioning properly. In our experience, we have found that the majority of accidents arising from the use of oil burning devices are due either to use of poorly designed apparatus, a lack of the ordinary safeguards or the use of a quality of oil that was unsuited to the equipment.

To CLEAN the water gage on a steam furnace without removing it, the Petro-Nokol Co. gives the following directions: First draw a cup of hot water from the boiler and pour a tablespoonful or two of muriatic acid into it. Close the water gage valves leading into the boiler. Open the pet-cock at bottom of gage and open for a second the top gage valve, which action will blow out the water in the gage. Close top valve immediately. Then submerge the end of the pet-cock into the cup of water. As the gage cools a vacuum is created and the solution rushes at once into the gage. Twiddle the solution in and out of the gage by opening and closing the top gage valve. This soon cleans all oil, grease and other matter in the glass. When completely cleaned, allow the solution to run out, and then open the water-gage valves.

Industrial Evaporator Practice and Design

A Properly Installed Evaporator Has Several Functions Which Often Justify Its Use for Large Quantities of Make-up. By S. E. Tray*

ONE OF THE CHIEF REQUISITES of a power plant, whether it be a central station or an industrial plant, is a constant supply of pure feedwater. In modern high efficiency central stations with little or no condenser leakage or opportunity for loss of condensate, the quantity required for makeup is relatively small and the investment in evaporators to supply pure makeup is a small part of the total investment. There are many cases, however, where industrial plants need large quantities of process steam which is not available as condensate for boiler feed. In such cases, it has been customary to consider evaporation prohibitive, but in the light of recent developments, there are certain conditions under which evaporators provide a solution of the feedwater problem.

When considering the installation of evaporators in a new or existing power plant, they should be evaluated not only as a means of producing distilled water but as a piece of equipment capable of performing several additional functions. This is especially true in cases where large quantities of water are to be evaporated and where the investment in evaporating equipment is a large part of the total. These additional uses of the evaporating equipment include that of heater and deaerator.

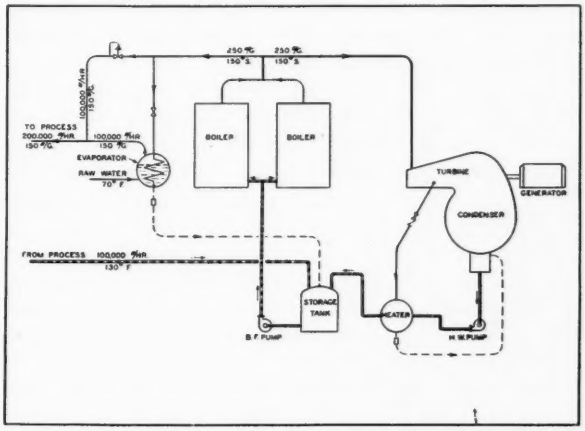
When used, the evaporator condenser acts as a feedwater heater of the indirect contact type and is placed in the feedwater system in such a manner as to reclaim the heat in the vapor to assist in raising the temperature of the incoming feedwater. As a deaerator, when the traps are properly vented, the oxygen content of the condensed steam can be reduced to a minimum; hence, if the evaporators are credited with these additional uses, it is sometimes possible to justify their expense on large quantities of makeup water, whereas considered only for distillation, the investment may not be warranted.

Types Available

For power plant work, evaporators are of two types, single and multiple effects. In connection with the use of these types, it should be borne in mind that a multiple effect, where the evaporators are connected in series, has the same capacity as a single effect, provided the initial steam pressure and temperature are the same. Steam consumption is reduced in proportion to the number of effects installed, however, and this economy is the only reason for the use of multiple effects which are naturally more expensive than single effect evaporators.

Evaporators are usually designed with a minimum temperature difference of 20 deg. F. between the incoming steam and outgoing vapor. This minimum difference is the point below which the rate of heat transfer of the evaporator becomes impaired due to poor circulation in the shell. The maximum temperature head of about 100 deg. F. is the limit beyond which violent ebullition of the water would require excessive separator space to prevent entrainment and carry-over.

Another recognized fact in evaporator design, sometimes overlooked, is that in multiple effects the heating surface in each effect must be slightly greater than in a single effect of the same capacity, since as the number of effects increases in a given temperature range, the temperature drop across each one becomes less. Because the decrease in temperature drop decreases the rate of heat transfer, a larger surface must be available for evaporation.



INDUSTRIAL EVAPORATOR INSTALLATION

Design of an evaporator system should be based not only on the requirements for distilled water but also on proper association with the heat balance of the entire plant. In some cases, the quantity and temperature of the condensate from a turbine will be sufficient to condense the vapor from a single effect evaporator. In many cases, however, multiple effects will be necessary in order not to reduce the overall plant economy by using additional condensing water which would have to be discharged to waste.

For central station practice, multiple effect evaporators are open to the very serious objection that they require considerable space for the large piping needed to handle the low pressure vapor, as well as a large number of auxiliaries, such as pumps and traps; hence, they crowd considerably the small space usually available for evaporators and for this reason, single or double effects are generally preferred for central stations. Even though the steam economy is less in this type, it does not affect greatly the overall economy because of the small amount of steam used.

Welded Construction

Out of the operating experiences gained at Deepwater, where steam is furnished for process work, have

*Sargent & Lundy, Inc., Chicago, Ill. From a paper presented before the Fifth Midwest Power Conference.

come two important features which should be incorporated in the general design of evaporators. The first is the inclusion, as an integral part of the evaporator, of a steam purifier designed to remove the last traces of impurities and carry-over in the vapor. This is essential since the evaporator is a small boiler operating without a dry pipe or adequate vapor space. Secondly, on large evaporators using steam under pressure in the coils, welded construction should be used on the shells to care for expansion caused by the difference in temperature between the incoming water and the outgoing vapor. Riveted construction, under such conditions, is extremely liable to leakage.

Industrial Application

The reducing valve evaporator system is perhaps the most interesting recent development in power plant practice. An example shown by the illustration represents an industrial power plant producing both electric energy and steam for process. Steam is required for the turbine at 250 lb. gage and 150-deg. superheat. The process steam requirement is 200,000 lb. per hr. at 150 lb. gage and the losses in the process amount to 100,000 lb. per hr. The process system receives 100,000 lb. per hr. directly from the boiler through a reducing valve and the additional 100,000 lb. from the evaporator system. The raw water enters the evaporator shell and remains entirely separate from the boiler system, which thus receives only distilled water.

Another important factor to be considered in evaporator practice is the place in the heat cycle occupied by the evaporator. Too much care cannot be taken in selecting this point and in general it may be stated that the higher the operating pressure, the greater is the ease and satisfaction of operation. This is due to several reasons, chief among which is the character of the scale formed under varying conditions of pressure and temperature. This, of course, is dependent on the nature of the available water and each installation should be carefully studied by itself.

Here again, though, the general observation may be made that higher temperatures are more favorable to the formation of an easily cracked scale, due primarily to the inverse solubility curve of calcium sulphate. In addition, boiling under low pressures introduces several complications, among them being severe spouting of the water with its resultant carry-over. Such carry-over may be as serious as in the boiler itself, especially when operating under high pressures, but it is interesting to note that when properly installed with purifiers on the vapor line and carefully operated, the carry-over from evaporators may be reduced to 0.1 gr. per gal., or less than 2 p.p.m.

Chemical Treatment

Chemical treatment is often used before evaporation, sometimes afterwards, so no discussion of evaporators would be complete without reference to this subject. The object of chemical treatment before evaporation is to produce a water that will form a hard brittle scale on the evaporator coils, capable of being removed by cracking. The cracking process is carried out by filling the evaporator shell with cold water and admitting steam to the coils which then expand, causing the scale to crack. The maximum capacity of the evaporator is available just after cracking and gradually decreases until such time as it becomes necessary to crack the scale again. The frequency of cracking depends, of course, on the nature of the water and the character of the scale formed and may vary from intervals of 4 hr. to a week.

In the same manner, the nature of the water determines the necessity for chemical treatment. Obviously, a water which forms a soft mud or sludge, due to bicarbonate hardness or other cause, must be treated to form a brittle scale capable of being removed by cracking. Unless this is done, the soft mud will build up on the tubes quite readily and reduce the evaporator capacity considerably in a short time.

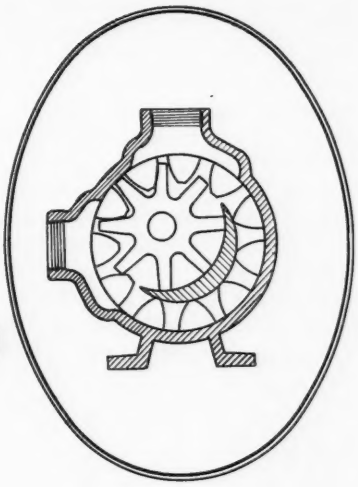
The problem resolves itself into determining whether it is more economical to install additional evaporator capacity with frequent outages for cracking and cleaning or to assume the additional expense of chemical treatment with increased evaporator performance. Pretreatment of evaporator feed may be accomplished by any of the usual softening agents but is usually not carried to as complete softening as is the case with boiler feedwater. All that is necessary is to remove the temporary hardness with lime and some coagulant such as sodium aluminate, allowing the sulphate scale formed from the permanent hardness to be removed by cracking.

Zeolite softening has also been used with some success, but since the degree of softening cannot be easily controlled with this method, in several instances the increase in sodium salts in the absence of continuous blowdown has been found to be quite conducive to carry-over in the evaporator. This is fully as serious as foaming and priming in the boiler itself, hence the possibility of such carry-over should be carefully studied when pretreatment is considered. This again depends on the nature of the available raw water.

After Treatment

Probably the greatest use of after treatment of evaporator feed comes in connection with the conditioning of boiler water to maintain certain accepted standards to inhibit embrittlement such as the sulphate—total alkalinity ratio, as recommended by the A.S.M.E. or the presence of soluble phosphate. This may be accomplished by the addition of sodium sulphate or any of the soluble phosphates, which are usually introduced in the condenser hotwell. Under certain conditions, sulphuric acid feed may be introduced after the evaporators, although usually because of the relatively small make-up required, the problem of control for small amounts of chemical becomes very complicated. Should the raw water tend to be acid in character, the evaporator will not increase the hydrogen ion value, which must be changed then by other means. In the case of some plants located on large lakes or other relatively stagnant waters which are subject to a semi-annual "turn-over," chemical treatment may be necessary only at periods when the upper layers of water contain high concentrations of organic materials, bicarbonates and other sludge forming matter. In the case of waters with high turbidity, the evaporators should be preceded by filters which will aid materially in keeping the evaporator clean and preventing carry-over.

DIESEL ENGINE UPKEEP



PART XIV. FUEL TRANSFER PUMP AND STORAGE AND DAY TANK MAINTENANCE. METHODS OF AVOIDING TROUBLE. WHEN AND HOW TO HEAT OIL. TANK CLEANING AND VENTILATION. ALARMS AND INDICATORS.

BY EDWARD J. KUNZE

MAINTENANCE of fuel-oil handling and storing equipment is not a difficult task but there are so many conveniences that may be employed to avoid troubles and to facilitate operation that careful consideration of this phase of Diesel engine upkeep is desirable.

Two distinct divisions of the fuel-oil system of a Diesel engine exist. The one including the fuel injection pump and what follows it to the engine, was discussed in the previous article of this series. The fuel supply pump or transfer pump and the storage and day tanks will be considered here. The transfer pump should not be expected to handle oil against an extremely high suction lift. The maximum suction lift permissible for oil is about 16 ft. A foot valve should be installed in the suction line unless the connections are such that the oil flows to the pump by gravity.

When reciprocating pumps are used for fuel transfer purposes, they should be provided with brass valves and metallic or other packing that will not be affected by the oil. Large air chambers, which may take the form of a standpipe, should also be provided to prevent pulsations of oil pressure due to the strokes of the pump. The speed of the pump should not exceed 20 strokes per min.

Motor-driven rotary pumps are popular for this kind of service because of their simplicity and their ability to handle large volumes of oil for comparatively small space requirement of pump unit. Frequently these pumps are of the two-propeller type. A unique design of rotary pump used for fuel oil transfer is shown in the headpiece of this article.

STORAGE TANKS

Fuel oil storage tanks may be made of steel or concrete. Concrete tanks should be painted thoroughly on the inside to prevent absorption of oil. They may be used for the storage of fuel oil when the liquid is heavier than 35 deg. Baumé but oil should not be turned into them earlier than six weeks after the construction of the tank. Where a large amount of fuel oil is carried in storage, a concrete tank is usually cheaper in construction than a steel tank. Concrete tanks should not be less than 13,000 gal. nor more than 300,000 gal. in capacity. A square tank is easier to make than a round one but it is more likely to crack. Circular concrete tanks should have convex bottoms as shown in Fig. 1. Storage tanks should be designed to withstand a full head of water corresponding to the tank depth. Concrete tanks should be reënforced with steel bars and wire netting.

If steel tanks are set vertically, the bottom should be made convex and it should be provided with a means for draining it periodically to remove any sediment or moisture that may have settled out. The outlet for fueling the engine should be a short distance above the

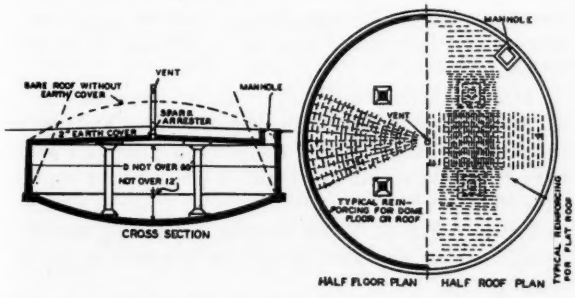


FIG. 1. TYPICAL REENFORCED CONCRETE FUEL OIL TANK

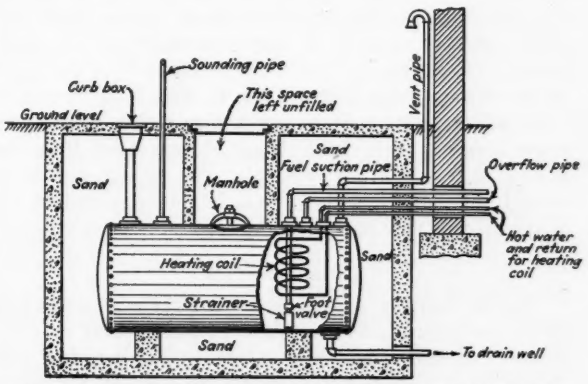


FIG. 2. UNDERGROUND FUEL OIL STORAGE TANK CONSTRUCTION RECOMMENDED BY THE DIESEL ENGINE MANUFACTURERS ASSOCIATION

convex bottom to insure delivery of clean oil. If set horizontally, it is best to have one end of the tank lower than the other and to provide a sump and drain cock. If the tank is installed below ground level, it is best to have it accessible on all sides and provide enough room to allow for periodical draining of the sump.

If a centrifuge has been installed in the fuel oil system, all oil drained out when removing sediment or water or which may have leaked out into the sump, may be reclaimed. An underground tank construction recommended by the Diesel Engine Manufacturers Association, is shown in Fig. 2. Since tank cars usually have a capacity of under 10,000 gal., the capacity of a single storage tank should be about 12,500 gal. depending upon

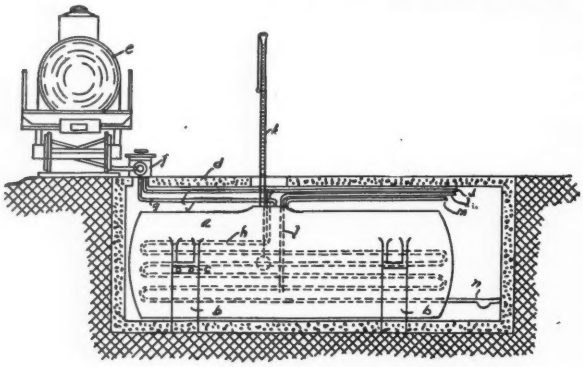


FIG. 3. ROLLERS PROVIDE FREE MOVEMENT DUE TO EXPANSION OR CONTRACTION OF TANK

the market availability of the fuel. If storage is in duplicate tanks, each should have a capacity of 10,000 gal.

Where tanks are very large, it is well to provide for expansion and contraction changes by having the end farthest from the pipe connections to the engine room, rest upon rollers C, Fig. 3, which may move upon the supports B. In this installation, K represents a gage for indicating the amount of oil in the tank. The suction pipe for the transfer pump is shown at L and the overflow pipe from the engine room at M. The water end of the steam heating coil H is provided with a trap N and the condensation is piped for return to the boiler room or to the sump in the case of heating by water.

All piping, except the return of the steam coil, enters the top of the tank. The piping should be installed with a swing joint so that any movement of the tank will either screw or unscrew the pipe connection a very small amount. It is best to filter the oil before it is delivered to the storage tank, hence filter F, Fig. 3, is provided. Such a filter, with a ¼-in. mesh wire screen which prevents large objects from being drawn over into the system, serves this purpose well. The piping should be so laid out that when the system is not in operation, all of the oil will flow back into the tank.

Tank Location

Before locating a storage tank, local municipal and insurance restrictions should be consulted and requirements complied with. For safety in storing, fuel oils should have a flash point above 125 deg. F. by closed cup test or 150 deg. by open cup test. Preference is given usually to above ground locations but if local conditions, such as those of the colder climates, require the tank to be buried, attention should be given to the features discussed, especially those which provide for a drain or sump to indicate leakage of any kind. If the tank is made in compartments, a channel running from underneath each compartment should connect to a channel at one side which should be protected by a manhole.

If the storage tank is located below ground level, it may be filled by gravity from a tank car that has been spotted on a siding near by. In this case, the transfer pump would be used to pump the oil from the storage tank to the day tank. If the storage tank is above ground, the transfer pump would be used between the tank car and the storage tank, hence it should be protected properly. As a motor-driven rotary pump, which is most suitable for this purpose, is a small unit, this protection is simple.

By locating the storage tank at the highest part of the property, where there is a slope, it is possible, especially where the tank is above ground, to have the oil feed the tank by gravity. Pipe or hose connections to tanks should be permanent. Dragging hose over the ground and dropping one end into an opening in the top of the tank is likely to introduce sand and other foreign matter into the fuel and cause trouble.

Heating Increases Fuel Fluidity

With the heavier oils and especially in colder climates, it is necessary, frequently, to heat the oil before

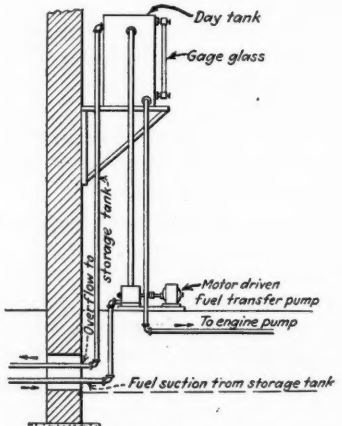


FIG. 4. FUEL SUPPLY SYSTEM WITH DAY TANK AS RECOMMENDED BY THE DIESEL ENGINE MANUFACTURERS ASSOCIATION

it can be pumped. In one case at a Palo Alto, California, plant the 14-16 deg. Baumé fuel oil used was so viscous that it required heating to 150 deg. F. to make it flow.

Heating is accomplished, usually, by steam or hot water coils as indicated in Fig. 3. The heating coil should be arranged about the suction pipe and should have no joints within the tank. Tank cars are supplied with coils to which connection may be made at the plant as shown in Fig. 3. When heating is required, therefore, a tank car so provided should be specified when purchasing fuel.

Required fluidity of fuel oil, expressed in standard terms, is 200 Saybolt Universal. If the fuel does not

have this fluidity at normal temperature, it must be heated until proper fluidity is secured. In moderate climates, fuels of 25 deg. Baumé or over do not require heating, while fuels between 18 and 25 deg. need to be warmed slightly and fuels less than 18 deg. must be heated. A simple heating device consists of a jacketed fuel reservoir through which hot water is circulated. This water may come from the engine jackets but should be heated further in coils passing through the exhaust manifold where high temperature may be obtained without danger. Electric heating methods may be used also but these are more expensive to operate.

Heating of the fuel oil without cost or effort, after the installation has been made, is accomplished in a unique manner in a Madison, S. D. plant where the reënforced concrete tank shown in Fig. 1 was located under the cooling-tower basin. This particular tank is divided into several compartments so that both light

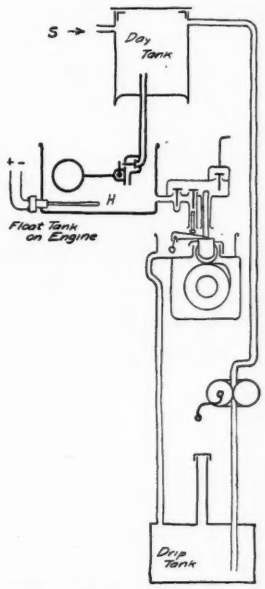


FIG. 5. ARRANGEMENT OF UNDER-FLOOR DRIP TANK AS AUXILIARY TO DAY TANK

and heavy oil may be stored. The light oil is used to start the engines, after which the supply is switched to the heavy oil. Division of the large tank also permits inspection and repair of any section but detection of a leak to the outside may be accomplished by having an accessible drain pit on one side into which lead channels underneath each section.

Fuel Level Determination Methods

Use of day tanks makes fuel consumption record keeping simpler and more accurate. They also provide a means for settling out water and other impurities from the fuel and assist in controlling the rate of flow to the engine. When they are located above the floor line, they should be provided with gage glasses that may be seen readily from the engine-room floor as shown in Fig. 4. When they are below floor level, they should have float or pressure-operated gages. Even with day tanks so provided, the storage tank fuel level determinations should not be omitted. Determination of the fuel consumed from the readings of the storage-tank level indicator serves as a check on the total consumption found by adding the consumptions of the individual engine units as estimated from their day tank readings.

For storage tanks located out of doors, a simple housing should be provided for the indicator which may be operated by a sounding pipe in which there is a float. Some engines draw directly from storage tanks without the intervention of a day tank. In such installations, a float or pressure operated indicator furnishes a fairly reliable means for measuring the fuel consumed and in such cases each engine should have its individual tank, for in no other way can the amount of fuel used by each engine be determined.

Tanks installed below floor level sometimes are provided with floats to permit using an overhead-gravity tank which is situated higher than the engine. This under-floor drip tank is vented to some point outside of the engine room so that the pressure in it is atmospheric, as shown in Fig. 5.

Ventilating pipes should terminate with a goose neck or be provided with a cap as shown in Fig. 5 to prevent admission of dirt and water and a fine gauze screen should be fitted across the open end of ventilating pipes of all tanks to prevent flames resulting from accidental ignition of issuing vapors from entering the tank through the pipe. The engine tank shown in Fig. 5 is provided with an electric bayonet heater H, which maintains the proper oil temperature automatically. The day tank may be supplied with fuel at S either by gravity from a supply tank or direct by the transfer pump. Oil is drawn from it by the auxiliary fuel pump and returns enter it from the overflow and from leakage from the pump and spray valves. Float-equipped tanks may be made considerably smaller than under-floor tanks which are used as reservoirs.

To avoid interruption in service because of fuel tanks running dry, each engine may be provided with a simple electrical alarm device.

Ventilate Tank Before Entering It

Sludge and sediment which gather inevitably at the bottom of fuel tanks are not always removed easily by flushing with warm water and usually require some manual application for thorough removal. Before entering a storage tank for any purpose, care should be taken to ventilate it thoroughly to remove suffocating gas. Even then, no open flame should be allowed in the tank or near the opening; no light, save an electric bulb with a wire guard, should ever be used. If the bulb is unguarded, it may break; the heat of the filament has ignited gases in a number of cases.

If natural airing is resorted to, at least 12 hr. should be taken for the airing process. Where it is necessary to enter the tank before this, ventilation may be accomplished by use of compressed air. If air is forced into the tank at about 45 lb. press. through a ½-in. line connected to the drain valve, the tank may be entered without danger after an hour's blow but the air injection should be continued while anyone is working in the tank, although its pressure may be reduced somewhat. This method requires a large amount of air but it saves considerable time.

Faraday—Genius

Hundredth Dis

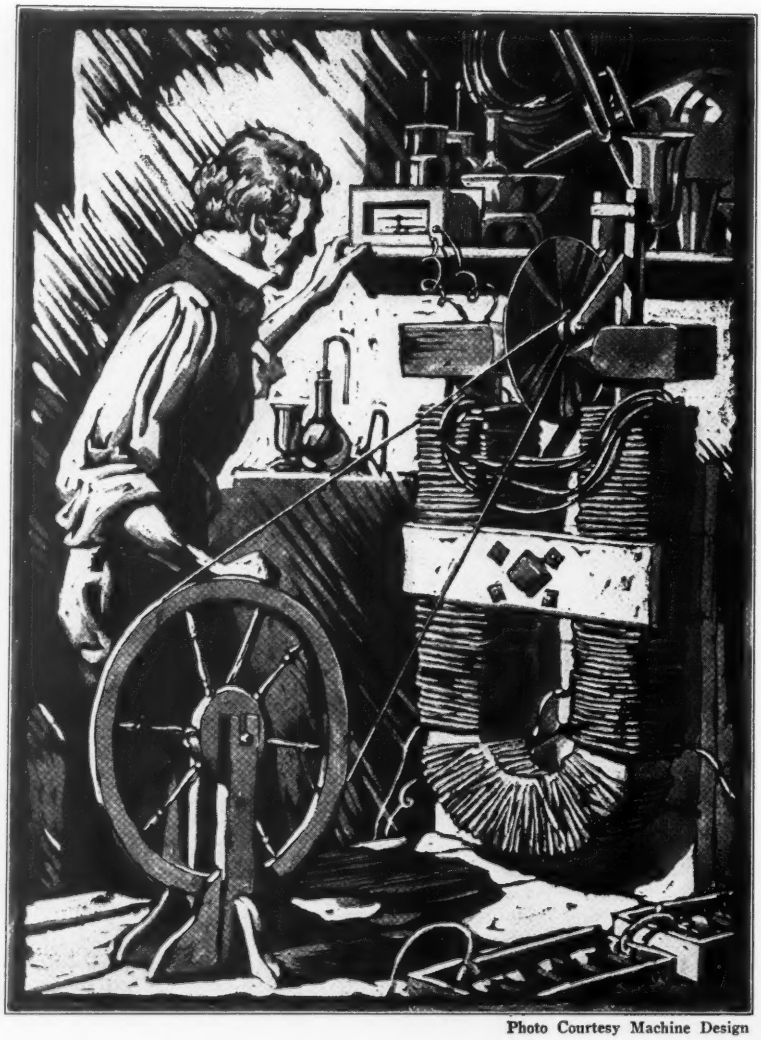


Photo Courtesy Machine Design

Michael Faraday and the Dynamo

A Great moment in the history of electrical engineering. On November 4, 1831, by spinning a copper disc between the poles of the Great horseshoe magnet of the Royal Society Faraday created the world's first direct current generator.

IN THE NEXT few months, a great deal will be heard about Michael Faraday, for 1931 marks the hundredth anniversary of his incomparable discovery of electromagnetic induction. A brilliant celebration in honor of Faraday is to be held the third week in September at London, where he carried out his experiments, and many of the foremost scientists of our day will attend the sessions. It happens that the centenary of James Clerk Maxwell falls at the same time: Maxwell interpreted into mathematical form the principles brought to light by Faraday. The celebration will thus have a double significance.

The story of Faraday's life and achievements is full of interest to engineers and laymen alike, whether told in brief outline, as here, or in several volumes. Born the son of an obscure blacksmith, and given only a meager education, he became, in the words of Tyndall, "the greatest experimental philosopher the world has even seen".

Like the American scientist, Franklin, Faraday in his early youth served as apprentice in a bookshop. He later explained how an article on electricity in a copy of the Encyclopaedia Britannica, which he was binding, first interested him in science. He then made what experiments he could in both chemistry and electricity; his original machine for producing static electricity has by good fortune been preserved, as have the sketches, in Franklin's own hand, of his design for similar apparatus.

Seeing by chance a sign announcing some lectures to be given on scientific subjects, Faraday borrowed the small sums necessary for admission and made careful notes of all that he heard. These notes were later brought to the attention of a famous chemist, Sir Humphrey Davy, and were the means of Faraday's acceptance as an assistant to Davy in the laboratories of the Royal Institution. When Davy went to the Continent to visit the wonders of scientific interest in various countries and to confer with other celebrated chemists, he took Faraday with him. After eighteen months of

Of The Dynamo

Anniversary of Michael Faraday's covery of Electromagnetic Induction

By Terry Mitchell

this, they returned to London and Faraday launched upon the 40 years of his magnificent service to research. The first period of his work was concerned chiefly with chemical investigations and studies of the technical methods which were to be the basis of his ultimate achievements.

Faraday's discovery of electromagnetic induction was by no means a matter of chance. For two hundred years before his time, scientists had known that lines of force of some kind surround a magnet, their effect being shown by the arrangement of iron filings into curved lines when vibrated on a plate above the magnet. Later it was found that an iron core, surrounded by a coil of copper wire, would become strongly magnetized when an electric current from a battery was run through the wire. As early as 1822, Faraday had begun to suspect that the converse should be true and had written in his notebook, "Convert magnetism into electricity."

But this, which has proved to be the foundation of nearly all of the electrical wonders we know and use, had never been done, and nearly ten long years went by before Faraday himself could accomplish the feat. He repeatedly tried to gain his object by placing an iron magnet in a helix of wire, the ends of which were then connected to a simple form of galvanometer; no current was observed to flow. Although baffled by the obstinate failure of the experiment, Faraday never lost faith in his idea that electricity and magnetism must be related. He kept turning his mind back to the problem. For many months he carried in his waistcoat pocket a straight piece of iron, about an inch in length, with a few turns of wire wrapped around it; this model he would take out and study at odd times in the effort to unravel the secret with the aid of sight and touch.

Other investigators were likewise pondering the same question; in 1824 it was discovered that a copper disk, rotating beneath a compass needle, caused it to swing in the same direction. This effect was duplicated in other tests, with apparatus arranged in various ways, and it seems to us now that such men as Ampere, Arago, Herschel and Sturgeon could hardly have failed to sense the meaning of what they observed. Faraday knew of their theories and again in 1828 tried vainly to make his magnet-and-coil combination produce a current. He had not yet learned that it was the relative *motion* of the two that was all important.

The statue of Faraday standing in the entrance hall of the Royal Institution shows him holding in his hand an iron ring with wires wound around it. The original ring, preserved in the museum of the Institution, is the one Faraday used in finding the present of the induced current for the first time (August 30, 1831). The ring he magnetized by running a current from a wet battery through a wire coiled on one side of it; a second insu-

Photo Courtesy General Electric Co.

FIG. 1. MICHAEL FARADAY, DISCOVERER OF ELECTRO-MAGNETIC INDUCTION

lated wire, wrapped on the other side, had its free ends joined over a magnetic needle placed three feet away. When the connection to the battery was *made* or *broken*, the needle oscillated—and Faraday saw the light.

In ten days devoted to the work, between that day and the fourth of November, he achieved what he had dreamed of doing for as many years, rapidly feeling his way from the ring to a bar of iron inside a coil, the bar being temporarily magnetized by touching it with other magnets; thence to the delicate effect of the current in a coil upon a second coil wound around it; from this to creating a current in a helix by thrusting a bar magnet into it; and then, by spinning a copper disc between the poles of the great horsehoe magnet of the Royal Society, the axis and edge of the disc being wired to a galvanometer, he created the *world's first direct-current generator;* finally, he moved a wire across the field of the magnet and found the desired effect, which he stated was caused by the *cutting* of the

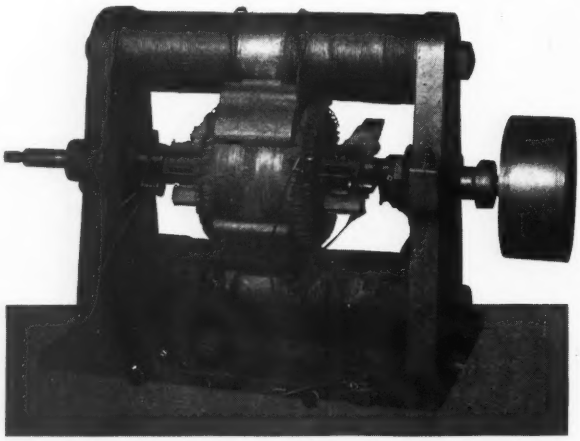


FIG. 2. THE JOINT DYNAMO MADE IN AMERICA CONSTRUCTED AT CORNELL UNIVERSITY IN 1875 BY WM. A. ANTHONY AND GEORGE S. MOLER

lines of force—the gist of the whole story, and the same lines had been seen for those two hundred years!

Shortly afterward, he produced sparks of electricity with currents from his magnet and wire, showed how the current would make fine wires turn red hot and that it would cause chemical changes in solutions. He developed several kinds of electrical machines or dynamos, his masterful experiments opening up a new world for investigators everywhere. In subsequent years, he evolved the principles of electro-magnetic and electro-chemical action; he discovered diamagnetism, and worked out the effects of magnetism on polarized light. Throughout a life of great labor, his genius shone upon everything he touched and his thousands of experiments, recorded accurately in his daily notes, show with what marvelous insight he handled technical problems of every kind. A study of his work and methods will repay anyone of scientific mind.

So earnest in the search for new knowledge was Faraday that he had time for nothing outside of his researches and lectures. He lived on an income averaging a few hundred dollars a year, refusing consultation work that would have paid him $25,000 or even more, in the same period. He never applied for patents on the things he discovered at such sacrifice, but promptly published his findings, to serve as a basis for useful inventions by others. Meanwhile his energies were turned toward new fields.

All his life he adhered to the strict religious teaching of an obscure sect called the Sandemanians, to which church his wife also belonged. Their beliefs corresponded closely to those of the Mennonites in Pennsylvania. When an invitation from Queen Victoria caused Faraday, who had been elected an elder, to miss the service one Sunday, he was put out of the church by the straight laced members. He continued to attend, however, and after ten years or more of excommunication was readmitted.

Honors by the score were rained upon him, from all over the Continent as well as England, but he declined to tax his strength with social engagements, and gave his extra income to charity. His manner was patient and kindly, reflecting the true greatness of his soul. He was, withal, very human, and it is said that he mixed a splendid bowl and wielded a good fork over a leg of mutton.

Electrical Engineers Elect Officers

CHARLES E. SKINNER, assistant director of engineering, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., was elected president of the American Institute of Electrical Engineers for the year beginning August 1, 1931, as announced at the annual meeting of the Institute held at Asheville, N. C., June 22, during the annual summer convention of the Institute. The other officers elected were: Vice-Presidents W. B. Kouwenhoven, Baltimore, Md.; W. E. Freeman, Lexington, Ky.; Paul H. Patton, Omaha, Neb.; A. W. Copley, San Francisco, Calif.; L. B. Chubbuck, Hamilton, Ont.—Directors L. W. Chubb, East Pittsburgh, Pa.; B. D. Hull, Dallas, Tex.; H. R. Woodrow, Brooklyn, N. Y.—National Treasurer W. I. Slichter, New York, N. Y. (reëlected).

These officers, together with the following hold-over officers, will constitute the Board of Directors for the next administrative year, beginning August 1: W. S. Lee (retiring president), Charlotte, N. C.; Harold B. Smith, Princeton, Mass.; H. V. Carpenter, Pullman, Wash.; G. C. Shaad, Lawrence, Kans.; I. E. Moultrop, Boston, Mass.; H. P. Charlesworth, New York, N. Y.; T. N. Lacy, Detroit, Mich.; J. Allen Johnson, Buffalo, N. Y.; A. M. MacCutcheon, Cleveland, Ohio; A. E. Bettis, Kansas City, Mo.; J. E. Kearns, Chicago, Ill.; F. W. Peek, Jr., Pittsfield, Mass.; C. E. Stephens, New York, N. Y.; A. B. Cooper, Toronto, Ont.; A. E. Knowlton and R. H. Tapscott, New York, N. Y.

WHEN NATURAL gas burns it produces a temperature of the flame of about 3600 deg. F., according to the research department of the Petroleum Heat and Power Co. The flame temperature of coal or fuel oil is about 3850 deg.; hydrogen, 3920 deg., and acetylene, 4160 deg. In the oxy-acetylene torch, where pure oxygen is used instead of air, which is only 23 per cent of oxygen, a temperature of 6000 deg. is reached.

ELECTRIC boilers have a high efficiency and have been successfully used where cheap power is available. They make an attractive offpeak load.

SIMPLIFIED VOLTAGE DROP CALCULATIONS

By F. C. De Weese

Assistant Engineer
Carolina Power & Light Co.

In a previous article on this subject the author described practical methods of determining voltage drop. In this present article the application of these methods are shown in the solution of actual problems.

IN THE PRECEDING article[1], we discussed the more practical methods of determining voltage drop. One of the most satisfactory ways in which the value of a thing can be proved, however, is by actual demonstrations; therefore, in order to illustrate the use of the tabulated values and the curves, a few problems will be given and the work carried through.

Example I: Assume a line 10 miles long, 4/0 copper, 11,000 v., 3-phase, 500 kw., 80 per cent p. f., 60 cycles, spacing 3 ft.

(a) Compute the voltage drop by use of values in Table I[2].

(b) Compute the voltage drop by use of values in Table II.

Solution for (a) $$V.D. = \frac{K.W.M. \times}{0.01 \times E_r} \qquad (4)$$

V.D. = total volts drop.

K.W.M. = kilowatt-miles

C = constant in table = volts drop per kw. per mile at 100 v.

E_r = the line voltage at the receiving end of the line.

From Table I, for 4/0 copper, at 3 ft. spacing, we find C = 7.638. Substituting in (4) we have

$$V.D. = \frac{500 \times 10 \times 7.638}{0.01 \times 11{,}000} = 347.18 \text{ v.}$$

$$347.18/110 = 3.156 \text{ per cent.}$$

Solution for (b) from Table II, 4/0 copper, 3 ft. spacing, the per cent drop per kw. is 0.0006312.

$$500 \times 10 \times 0.0006312 = 3.156 \text{ per cent.}$$

Example II: Assume a line 17 mi. long, 2/0 copper, 11,000 v., 450 kw., 80 per cent p. f., 60 cycles, 5 ft. spacing.

(a) Compute the voltage drop, at 80 per cent p. f. using Table II.

(b) Find the drop at 95 per cent p. f.

(c) How much load will this line carry at 90 per cent p. f., with the same drop as at 80 per cent p. f.?

Solution for (a) from Table II, 2/0 copper, 5 ft., we find 0.0008203.

$$450 \times 17 \times 0.0008203 = 6.275 \text{ per cent.}$$

Solution for (b) on Fig. 3, corresponding to 2/0 and 95 per cent p. f. is 1.44.

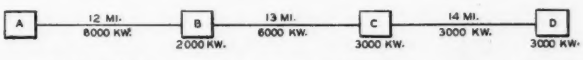
$$6.275/1.44 = 4.336 \text{ per cent drop, at 95 per cent p. f.}$$

Solution for (c) at 90 per cent p. f., Fig. 3, 2/0 is 1.243.

$$450 \times 1.243 = 559 \text{ kw. at 90 per cent p. f.}$$

Example III. Assume a line 120 miles long, 110 kv., 4/0 copper, 20,000 kw., 80 per cent p. f., 13 ft. spacing. What is the voltage drop?

It is to be noted, that we do not have any table values for 110 kv. This however, will not prevent the solution to this problem. From Table I, 4/0 copper, 13 ft. spacing, we have a drop of 9.055 volts, for 1 kw., at 100 volts. As explained in the last paragraph, on page 5, if we drop two places from 110,000, making 1100 and square this value, then divide this into 9.055,



we shall obtain a figure representing the per cent drop, per kw., at 110 kv.

$$C = \frac{9.055}{(1100)^2} = 0.0000074834$$

$$120 \times 20{,}000 \times 0.0000074834 = 17.96 \text{ per cent drop.}$$

From Fig. 1, for 120 mi., the per cent correction is 3.11 per cent.

$$17.96 - 3.11 = 14.85 \text{ per cent net drop.}$$

The exact solution for the above problem, by the convergent series is 15.04 per cent.

$$15.04 - 14.85 = 0.19 \text{ per cent error.}$$

From this you can see that you are able to obtain the answer within 19/100 of one per cent, by two settings on a slide rule. On the other hand, it requires at least an hour's time to make the rigorous solution with a calculating machine. To make the solution, without a machine is almost impossible, as the work must be carried out to at least six decimal places, which you know, is not within the limits of slide rule work.

Example IV: Suppose that in example III, this 120-mi. line was 25 instead of 60 cycles. What would the voltage drop have been?

The equivalent 60-cycle length would be $25/60 \times 120 = 50$ mi.

$$20{,}000 \times 50 \times 0.0000074834 = 7.4834 \text{ per cent.}$$

From Fig. 1, for 50 mi., the correction is 0.54 per cent.

$$7.48 - 0.54 = 6.94 \text{ per cent net drop.}$$

Example V: This example is illustrated by the sketch. Length of line from A to D 41 mi., No. 1 copper, 66 kv., 7 ft. spacing, 60 cycles, 80 per cent p. f. What is the total voltage drop?

There are several different methods by which the voltage drop in circuits, having loads taken off at different points, may be calculated, any one of which is

[1]May 15, 1931 issue, page 558.
[2]The tables and figures referred to appeared in the preceding article in the May 15 issue.

sufficiently accurate for all practical purposes. The shortest of these will be given first.

(1) $14 \times 3000 = 42{,}000$ K.W.M. C to D
$15 \times 6000 = 90{,}000$ K.W.M. B to C
$12 \times 8000 = 96{,}000$ K.W.M. A to B
Total K.W.M. 228,000

For No. 1 copper, 7 ft. spacing, Table II, we find 0.00002983.

$$228{,}000 \times 0.00002983 = 6.801 \text{ per cent.}$$

(2) Load center method.
$41 \times 3000 = 123{,}000$ K.W.M. due to load at D
$27 \times 3000 = 81{,}000$ K.W.M. due to load at C
$12 \times 2000 = 24{,}000$ K.W.M. due to load at B
Totals 8000 228,000

$$\text{Load center} = \frac{228{,}000}{8000} = 28.5 \text{ miles from A.}$$

Thus, it will be seen that this line will carry 8000 kw. 28.5 mi., with the same drop as for the loads given. $8000 \times 28.5 \times 0.00002983 = 6.801$ per cent, as before.

As above mentioned, these results are sufficiently accurate; however, if it is desired to know what the actual drop is (neglecting charging current) the following method may be used:

(3) From Table I, we find the drop for No. 1 copper, 7 ft. spacing, to be 12.996 v. From this value, the drop in each section of the line will be computed. In this way, the voltage at each of the loads, A, B, and C, will be shown. Inasmuch as the volts drop, in Table I, are based on 100 v., in order to determine the denominator of the equation, it will be necessary to point off two places, from the right, for the values of voltage at A, B and C.

$$\frac{14 \times 3000 \times 12.996}{660} = 827 \text{ v. drop, C to D}$$

$$66{,}000 + 827 = 66{,}827 \text{ v. at C.}$$

Pointing off two places, we have 668.27.

$$\frac{15 \times 6000 \times 12.996}{668.27} = 1750 \text{ v. drop, B to C}$$

$$66{,}827 + 1750 = 68{,}577 \text{ v. at B}$$

$$\frac{12 \times 8000 \times 12.996}{685.77} = 1819 \text{ v. drop, A to B.}$$

$$\text{Total drop} = 827 + 1750 + 1819 = 4396 \text{ v.}$$

$$\frac{4396}{66{,}000} \times 100 = 6.66 \text{ per cent.}$$

Error by first two methods $6.801 - 6.66 = 0.141$ per cent.

Certainly no one would expect you to go through all of the extra work, as given in (3) for a mere 14/100 of one per cent.

Example VI: Suppose the problem is one for the distribution engineer and he wishes to know what size wire will be required to carry 550 kw., ¾ mile, at 400 v., 95 per cent p. f., 3 ft. spacing, with a drop of not to exceed 5 per cent.

For this problem we have all necessary values except, the v. drop per kw. per mile.

$$\frac{0.75 \times 550 \times C}{40} = 200 \text{ v. drop} = 5 \text{ per cent.}$$

$$C = 8000/412.5 = 19.393 \text{ v.}$$

From Table I, we find the nearest smaller value to this, at 3 ft. spacing, to be 19.323, which corresponds to No. 4 solid copper. Also, from the power factor ratio curve, Fig. 1, for No. 4 copper, the factor in the right-hand margin is 1.2.

$$\frac{19.323}{1.2} = 16.102, \text{ the drop at 95 per cent p. f.}$$

$$\frac{0.75 \times 550 \times 16.102}{40} = 166 \text{ v. drop. Equals 4.15 per cent.}$$

The answer to the foregoing problem is to use No. 4 solid copper, for which the drop will be 4.15 per cent. This would allow an increase in load of 0.85 per cent, without exceeding the allowable 5 per cent.

It should be particularly noted, that in no case has it been necessary to refer to the resistance of reactance of the conductor, nor has it been necessary to know the value of the load current. It is only necessary to have the voltage at which the load is transmitted, the length of the line and the power factor.

When using a method of this kind, the accuracy of the result, for any problem, will depend upon the correctness of the tabulated values. Unless great care is exercised in making the calculations for the values, as compiled in the tables, the final results will not be correct. The tabulated values were compiled from calculations made by using a four-place table of resistances and reactance, corrected for effective 60-cycle resistance.

A. S. T. M. Elects Clements President

ANNOUNCEMENT is made of the election of Frank O. Clements, Technical Director, Research Laboratories, General Motors Corp., Detroit, Michigan, as president of the American Society for Testing Materials for the ensuing year. Mr. Clements is a graduate of Otterbein College, Ohio, has received from it degrees of A.B., M.A., and D.Sc., and also holds the M.Sc. degree from Ohio State University. He was Assistant Chemist, Pennsylvania RR. 1899-1903; Principal Assistant Chemist, Union Pacific RR. 1903-05; Chief Chemist and Engineer of Tests, National Cash Register Co., 1905-1917; Director of Research, Dayton Metal Products Co., 1917-1920; and Technical Director, General Motors Research Laboratories, 1920 to date.

Samuel T. Wagner, Consulting Engineer, Reading Co., Philadelphia, Pa., was elected vice president. Members of the Executive Committee elected were: Arthur W. Carprenter, Manager, Testing Laboratories, B. F. Goodrich Co., Akron, Ohio; Kenneth B. Cook, Technical Manager, Manville Jenckes Co., Pawtucket, Rhode Island; J. B. Johnson, Chief, Material Branch, Material Division, U. S. Army Air Corps, Wright Field, Dayton; George C. D. Lenth, Consulting Engineer, Chicago, Ill.; O. L. Moore, Engineer of Tests, Universal Atlas Cement Co., Chicago, Ill.

Volume Control of Refrigeration Compressors

CONSTANT SPEED VERTICAL AND HORIZONTAL COMPRESSOR CAPACITY CAN BE REGULATED EFFICIENTLY AT CONSTANT SUCTION PRESSURE BY CLEARANCE POCKETS

CAPACITY CONTROL of ice or refrigeration plant compressors is desirable in order to reduce the total power consumption at partial loads. On a constant speed constant capacity compressor with the condenser pressure fixed by the cooling water temperature, a reduction in capacity means a reduction in suction pressure. As a drop of one pound in the suction pressure decreases the refrigerating effect about three per cent and increases the power consumption about 2½ per cent, the necessity for some other method of capacity control is apparent.

With steam engine drive, this was easily accomplished but with the advent of the constant speed synchronous or induction motor drive such regulation is

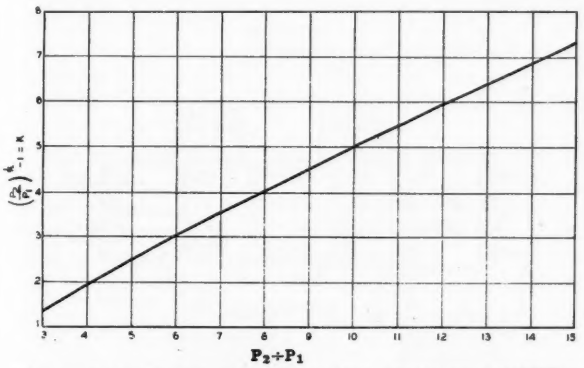


FIG. 1. VALUES OF K FOR CALCULATING VOLUMETRIC EFFICIENCY

impossible. The simplest arrangement for constant speed regulation in a large plant is to have a number of machines of different sizes so proportioned that the desired capacity can be obtained by combinations of different units. In small plants this is not possible while in large plants the higher efficiency and lower unit costs of large machines must be considered when laying the plant out. Another somewhat similar method is to have one motor drive two compressors so arranged with couplings that one can be disconnected to give the desired capacity reduction.

Clearance pocket control, is however, the most satisfactory solution of the problem. These pockets are arranged around the compressor cylinder so that by means of auxiliary valves they can be opened and in this way increase the cylinder clearance. Increased clearance reduces the volumetric efficiency of the machine and cuts down the power consumption in about the same ratio. Because of the fact that the friction horsepower is almost constant regardless of the compressor load, this increases the power consumption per ton of refrigerating capacity at the lower loads but results in a considerable saving over operation at lower suction pressures.

Indicator cards in Fig. 2 show low-pressure cylinder conditions at full, three quarters and half capacity. The indicated horsepower of the 50 per cent capacity cards is about 55 per cent of the full capacity cards. The gas trapped in the clearance volume re-expands on the back stroke and gives back approximately as much work as was put into it when compressed.

The effect of a given clearance volume depends upon the ratio of compression, the higher this ratio the greater the effect of clearance, C, on the capacity. The total volume of the cylinder is $1 + C$ and from the relation for adiabatic expansion $P_1V_1^n = P_2V_2^n$ the volume of the gas trapped in the clearance volume will be $C\ (P_2 \div P_1)^{1/n}$ when expanded from the final pressure P_2 to the suction pressure P_1. The volumetric efficiency E is equal to $1 + C - C\ (P_2 \div P_1)^{1/n}$. Combining these equations and calling $\left(\frac{P_2}{P_1}\right)^{1/n} - 1 = K$ the volumetric efficiency E is given by

$$E = 1 - CK$$

The value of K for different compression ratios is given by Fig. 1. On a compressor with 5 per cent clearance

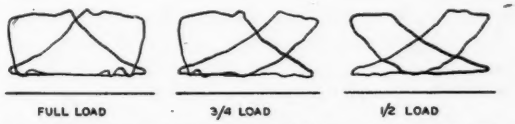


FIG. 2. LOW PRESSURE INDICATOR CARDS FROM AN INGERSOLL-RAND COMPRESSOR WITH CLEARANCE POCKETS IN EACH HEAD

and with $P_2 \div P_1 = 5$ the volumetric efficiency would be $1 - (0.05 \times 2.5)$ or 87.5 per cent. For half capacity E $= 43.75$ and the clearance, C, would have to be $(1 - 43.75) \div 2.5$ or 22.5 per cent. For 0 capacity the clearance would have to be $1 \div 2.5$ or 40 per cent of the piston displacement. With a ratio of $P_2 \div P_1 = 10$, a 5 per cent clearance would give a volumetric efficiency of about 75 per cent. For half capacity the clearance would have to be only 12.5 per cent and for 0 capacity about 20 per cent. The additional clearance necessary is obtained by adding clearance pockets.

These pockets are designed differently on different compressors and are sometimes variable, so that any desired intermediate capacity can be obtained, or in fixed steps such as 100, 50 and 0 or 100, 75 and 50 per cent. One of the former type as used by the Frick Co. on its vertical compressors is shown in detail by Fig. 3. By means of the handwheel, the clearance can be adjusted from the minimum, which is as small as possible for highest capacity, to a volume which gives a reduction in capacity of around 50 per cent. The movable piston can be set and left at any point within its range.

The cylinders are located as shown by Fig. 4 with the ports entering the main compressor cylinder close

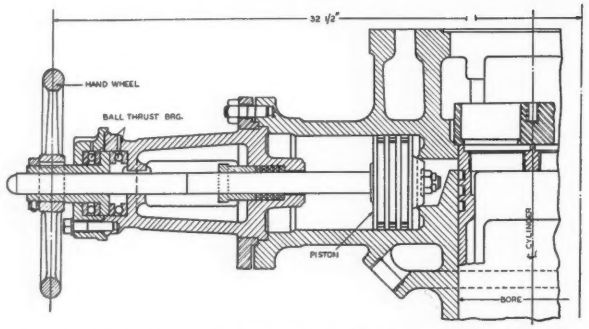


FIG. 3. DETAILS OF A FRICK 8 BY 8-IN. VERTICAL COMPRESSOR CAPACITY CONTROL CYLINDER

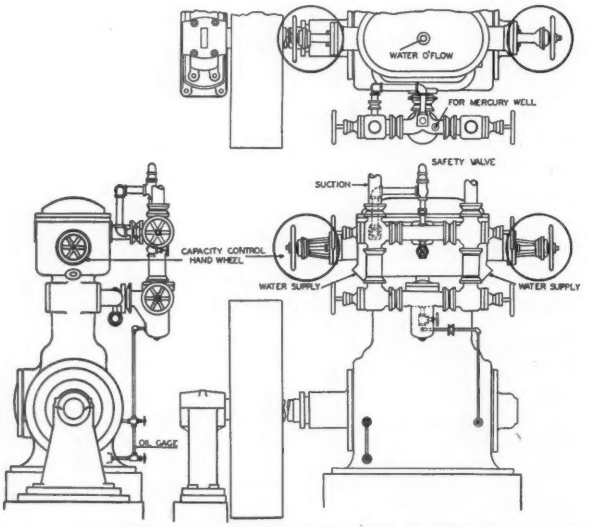


FIG. 4. LOCATION OF THE CLEARANCE POCKETS ON THE FRICK VERTICAL COMPRESSOR

to the head end. This permits the spring loaded safety head construction of this company to be retained without increasing the net compressor clearance or interfering with the valves. The clearance pocket is also water jacketed and it is said that with this design the discharge temperature at reduced capacity is little if any higher than at full load.

Capacity control valve details of the De La Vergne vertical are shown in Fig. 5. This device, which can be attached to the standard compressor, consists of a cast iron liner, inserted in the upper end of the cylinder, which rests on the upper end of the cylinder with a gas tight joint. A recess at the lower end of the liner affords a seat for the valve assembly. In normal operation, the valve is in its lowest position but for reduced capacity the entire valve assembly is raised by means of the handwheel until the cylinder clearance has been increased to the desired point. Regulation may be from maximum capacity to complete unloading.

On their horizontal machines, this company normally uses three fixed pockets in the head. These pockets when opened by the handwheel increase the clearance by an amount stamped on a small brass plate attached to the cylinder near the valve. The pockets are so proportioned that when the valve or valves are opened the clearance obtained is usually 4, 8, 12 per cent or some combination of these three. By opening the proper valve

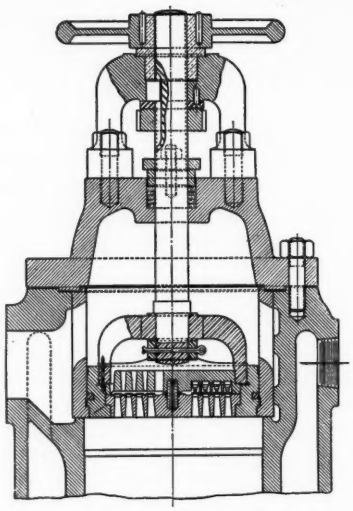


FIG. 5. VARIABLE CAPACITY CONTROL VALVE OF THE DE LA VERGNE VERTICAL COMPRESSOR

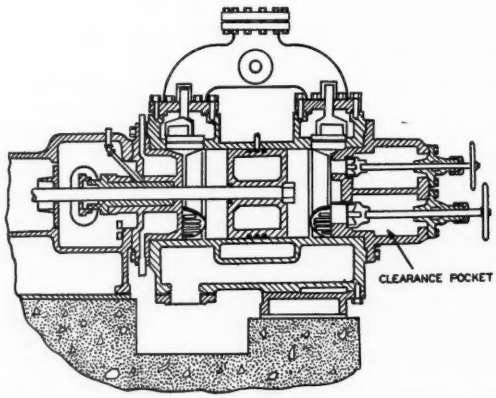


FIG. 6. WORTHINGTON HORIZONTAL MACHINE WITH TWO CLEARANCE POCKETS ON THE SAME END

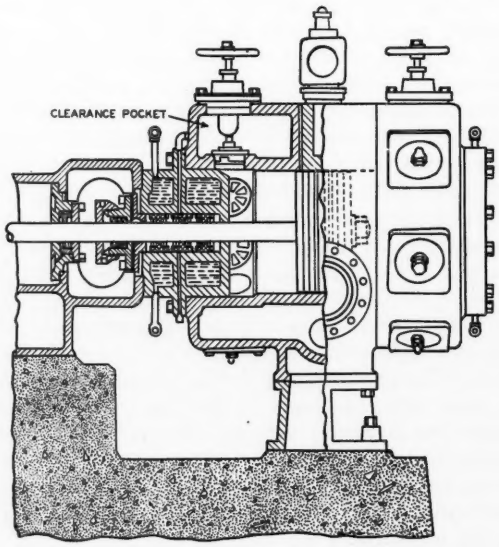


FIG. 7. INGERSOLL-RAND HORIZONTAL COMPRESSOR WITH CLEARANCE POCKETS ON BOTH ENDS

the clearance of one end can then be made 4, 8, 12, 16, 20 or 24 per cent, the last value usually being sufficient to unload one end completely, thereby reducing the capacity of the whole machine 50 per cent.

They have also built compressors with four pockets, two on each end of the cylinder. These pockets are cast into the cylinder and are of such a size that the compressor may be unloaded to 50 per cent. This arrangement gives balanced unloading and reduces the W R^2 effect required for the flywheel.

Fixed clearance pockets in the head of a horizontal Worthington machine are shown by Fig. 6, this particular machine having but two pockets. The clearance pocket arrangement used by Ingersoll-Rand on horizontal machines is shown by Fig. 7. Pockets are cast integral with the cylinder, one on each end, and each pocket reduced the capacity of that end 50 per cent, giving 100, 75 or 50 per cent capacity. Cards from the low-pressure cylinder of a machine of this type are shown by Fig. 2. On two stage units clearance volume is, of course, added simultaneously to both high and low pressure cylinders so as to maintain the load balance.

Clearance control makes possible the efficient operation of constant speed machines at partial load without reducing the suction pressure. Such control is essential for economy in all direct connected motor driven units and on the majority of belt driven units because of the expense of variable speed motors and control.

Osage 200,000-Hp. Project Nears Completion

SIX 23,888-KV-A. OUTDOOR MAIN GENERATORS DRIVEN BY 33,500-HP. FRANCIS WATER WHEELS, WITH STATION SERVICE FROM TWO 3025-HP. UNITS, FORM INITIAL INSTALLATION

OSAGE HYDROELECTRIC POWER PLANT now under construction for the Union Electric Light and Power Co. is on the Osage River about four miles upstream from the town of Bagnell, Mo., and about 125 mi. from Kansas City, 35 mi. from Jefferson City and 135 mi. from St. Louis.

Storage reservoir created by the construction of the dam will have an area of 86 sq. mi. or approximately 55,000 acres. Upper reaches of the reservoir will extend upstream from the dam approximately 125 mi. The maximum draw-down proposed is 30 ft.

The concrete gravity dam, approximately 2580 ft. long, consists of a power station section 511 ft. long, a spillway section 520 ft. long and two nonoverflow retaining sections adjacent to the river bank. The dam supports a concrete highway structure, which includes a 20-ft. roadway and a 3-ft. sidewalk, extending the entire length of the dam.

Substructure of the power station is of mass and reënforced concrete founded on rock. The portion containing the scroll cases and draft tubes is constructed for an initial installation of six main units and two station service units with provisions for two future main units. For the two future units, the headworks, portions of the draft tube piers and portions of the downstream wall will be constructed at this time. No superstructure other than an individual metal enclosure will be provided over each generating unit.

Intake or headworks for the power station will contain all necessary head gates and appurtenances, stop logs and trash racks. A concrete skimmer wall extending about 30 ft. below the maximum headwater level forms an integral part of the headworks. Head gates for each main unit are of structural steel, 23 ft. wide by 26 ft. high, of the fixed roller type. For the station service units, two structural steel head gates of the sliding type, each 7 ft. wide by 10 ft. high, are provided. Vertical trash racks are installed upstream from the gates and trash rack guides are so arranged that the trash racks can be replaced by stop logs, in order that the intake of any unit may be unwatered. A motor-operated rake cleans the trash racks.

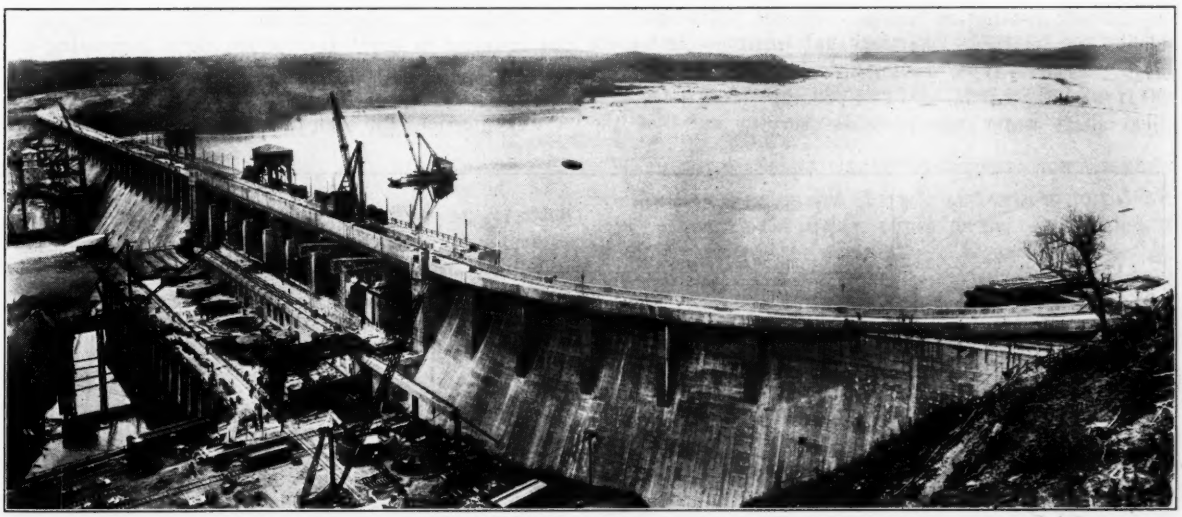


FIG. 1. OSAGE DEVELOPMENT UNDER CONSTRUCTION NEAR BAGNELL, MO.

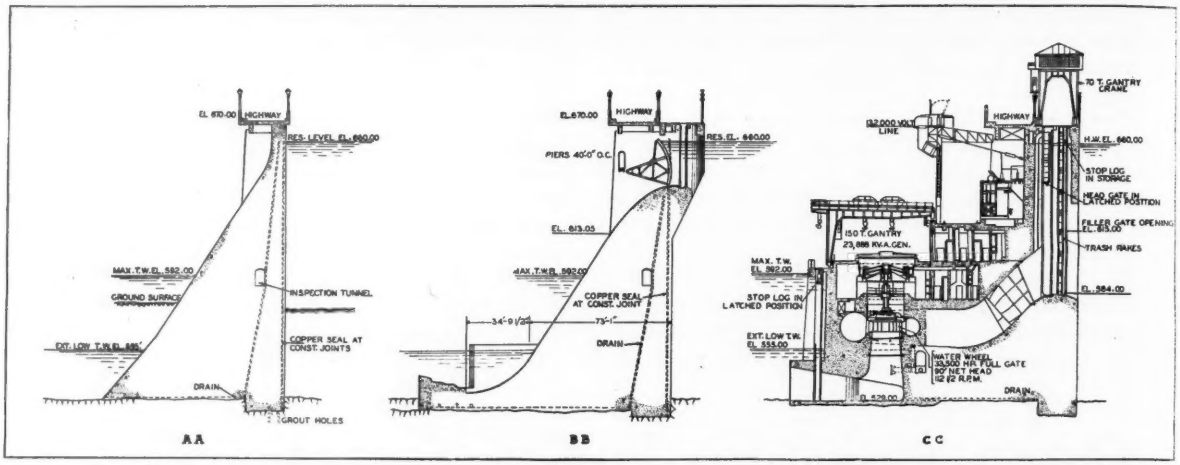


FIG. 2. CROSS-SECTIONS THROUGH POWER HOUSE, SPILLWAY AND DAM AT OSAGE DEVELOPMENT. SECTIONS AS INDICATED IN FIG. 3

A short tailrace extends approximately 200 ft. downstream from the power station. A gravity wall adjoining the power station at the east shore protects the river bank from erosion and supports the embankment under the permanent railroad track entering the power station.

Draft tubes of the elbow type have plate steel liners for the upper end of the vertical section. The draft tubes discharge directly into the river with provision for stop logs at the draft tube exits.

The spillway, equipped with 12 Tainter gates, each 34 ft. wide by 23 ft. high, will be used to control the reservoir water level during flood periods. Concrete piers between the gate openings support the highway and operating platform above the crest of the spillway. A stepped apron is provided at the toe of the spillway section to reduce erosion of the river bed below the dam to a minimum. A concrete retaining wall extends 50 ft. downstream from the edge of the apron at the west end of the spillway to protect the river bank from erosion due to the flow of water over the spillway.

Two traveling electric gantry cranes operate the Tainter gates and head gates and handle the stop logs and trash racks. One of these cranes has an auxiliary gasoline electric drive for emergency service.

Initial installation consists of six Allis-Chalmers 33,500-hp. (full gate) vertical-shaft main water wheels of the Francis type, designed for normal net head of 90 ft. at 112.5 r.p.m., and two 3025-hp. (full gate) vertical shaft water wheel station service units of the Francis type, designed for a normal net head of 90 ft. at 327.3 r.p.m. Ultimately there will be eight 33,500-hp. main units and two 3025-hp. station service units.

Initial generators consist of six Westinghouse 23,888-kv-a., 90 per cent power-factor, 13,800-v., 3-phase, 60-cycle, 112.5-r.p.m., umbrella type, vertical-shaft main generators and two 3000-kv-a., 70 per cent power-factor, 2300-v., 3-phase, 60-cycle, 327.3-r.p.m. vertical shaft station service generators.

Main power transformer banks at the level of the roof of the electrical bay, between the headworks and the generator bay consist initially of three 60,000-kv-a. main banks. Each bank consists of three General Electric single-phase transformers rated 13,333/20,000 kv-a., 13,800-132,000 v. The 20,000-kv-a. rating will be obtained by means of air blast equipment. One spare transformer will be provided for emergency use. The neutral of each transformer bank will be solidly grounded through a disconnecting switch.

Initially a pair of two generating units will be connected, through their respective generator oil circuit breakers, to each 60,000-kv-a. transformer bank. Each transformer bank is connected directly to the transmission line without high tension oil circuit breakers.

Ultimately a sectionalized 13,800-v. station bus will be installed to which four of the eight generating units will be connected through their respective generator oil circuit breakers.

Connections for each of the four remaining generat-

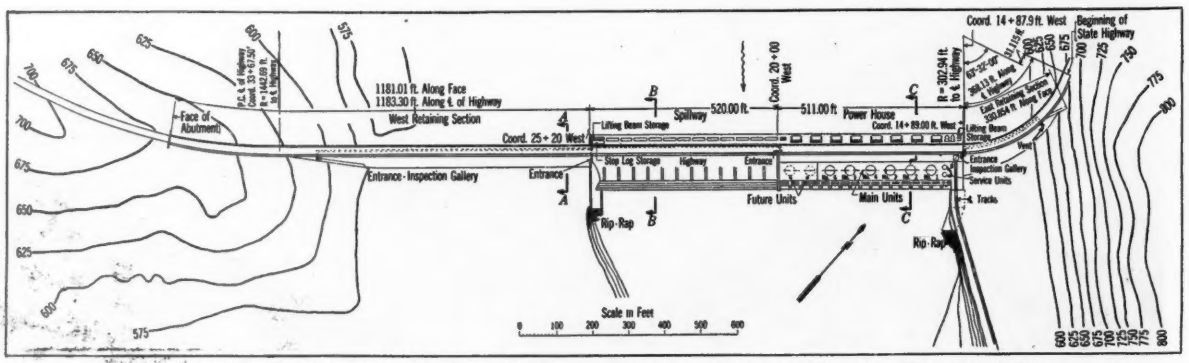


FIG. 3. GENERAL PLAN OF DAM, SPILLWAY SECTION AND POWER HOUSE AT OSAGE

ing units will be arranged to form a generator-transformer-line unit, with an oil circuit breaker connection to the 13,800-v. station bus, interposed between the generator and transformer oil circuit breakers.

Essential station auxiliaries receive power at 2300 v. from a single bus system divided into three sections by two sectionalizing oil circuit breakers. Each of the 3000 kv-a. water wheel driven generators are connected to an end section of the 2300-v. bus. Ultimately a 3000-kv-a., 13,800-2400-v., 3-phase transformer will be connected to the center section of the 2300-v. bus. The less important auxiliaries will receive power at 460 v. from two banks of 2400-480-v. transformers.

Main control switchboard consists of a combined bench and vertical type of switchboard and will control the generators, transformer banks and transmission lines. Auxiliary switchboards for the control and distribution of power for auxiliary services are provided. Two storage batteries, together with charging equipment provide for the operation of oil circuit breakers, emergency lighting and miscellaneous services.

Initially the output of the Osage Power Plant will be transmitted at 132,000 v., 3-phase, 60 cycles over three lines to the Union Electric Light and Power Co.'s substations located at Rivermines, Mo., and at St. Louis, Mo. Ultimately there will be a total of four lines.

Lightning arrester equipment, together with carrier current coupling capacitors for communication, will be mounted on the transmission line getaway structure on the roof of the electrical bay between the headworks and the generator bay.

Testing Rubber Devices for Use on High Voltage Equipment

THE STEADILY decreasing fatalities among electrical workers in a great mid-Western power and light company can be credited in a considerable measure to the rubber devices illustrated in the dummy man shown on the contents page of this issue.

This company calls in all rubber equipment every ninety days and tests each piece for defects and weaknesses. It is because of this frequent and thorough testing that the increased efficiency is due. One entire department is given over to this laboratory testing.

Four thousand volts are impressed across each device and any with the slightest defect are discarded. No mending of devices is ever done.

Rubber safety devices are continually being improved and their number added to, practically every part of the worker's body now being protected. The slightest defect in this equipment, however, may render it useless, so laboratory testing has been developed to locate these weak places before the actual break occurs.

Many thousands of dollars monthly are spent by this one firm in providing rubber protection to its hundreds of workmen for the replacement charges are high. A twelve dollar rubber blanket discarded for a slight defect is worth but twenty-five cents in the junk box and other devices in proportion.

NEVER LOOK directly at an electric arc without protecting the eyes with colored glasses.

George Washington—Engineer

BY JAMES HAY, JR.

GEORGE WASHINGTON, whose Bicentennial is to be celebrated all over the world next year, could have achieved engineering fame equal to his renown as a victorious soldier and a wise statesman if he had not spent half of his adult years in public service.

When this country does homage to Washington during more than nine months in 1932 in commemoration of his 200th birthday anniversary, it will pay tribute to a man who, because of his interest in the then Western frontier, often explored the Blue Ridge and Allegheny Mountains and the territory beyond them so

WASHINGTON AS A SURVEYOR

that he might map water routes and highways to improve transportation facilities between the West and the Atlantic seaboard.

Before the Revolutionary War he had worked out in detail a scheme for using the Potomac River as a channel of commerce with the West, had formed the Potomac River Co. to carry out the project and was optimistic of its early success.

WASHINGTON PLANS GREAT TRANSPORTATION SYSTEM

In 1784, having won the war and retired to private life, he formulated precise plans for the construction of a highway across the mountains to be used as a portage between the two water routes comprised in the Potomac and its tributaries on the one side and the Ohio and its streams on the other, a gigantic project for transportation between the Great Lakes and the Atlantic Ocean. He succeeded in bringing into existence the James River Co. and the Potomac River Co. to carry out the plan and was elected president of both companies.

Since the Potomac River Co. was charged with the bigger part of the work, it was to this concern that Washington gave more attention, time and labor. Its

manager, James Rumsey, was a man of high reputation in the engineering profession and an inventor as well. Rumsey's first task, always with the advice and coöperation of Washington, was to use the Potomac for transportation as far westward as possible, with canals built around the non-navigable stretches at Great Falls just above Washington, the Shenandoah Falls at Harper's Ferry, and the Seneca Falls between the other two. The plans were drawn, labor employed and work begun, most of it consisting of the blasting away of rock at the Shenandoah and Seneca Falls. Then came a big setback to the progress of the undertaking. Washington, answering the unanimous call of his countrymen, became the first president of the republic and naturally was obliged to leave the supervision of the company to others.

As a result, its chapter of tragedies began. After struggling against financial handicaps and political opposition through the rest of Washington's life, the Potomac River Co. collapsed at the end of 36 yr. of an existence which had resulted in the expenditure of $729,380.

Washington's Judgment Confirmed

But this was not because there had been any shortcoming in Washington's vision or any defect in his plans to accomplish a gigantic improvement. The proof of this lies in the fact that the Chesapeake and Ohio Canal Co. used the route which he had mapped and still later, the Baltimore and Ohio Railroad Co., by following the same route, further vindicated his judgment. More than a quarter of a century after he had mapped the highway to serve as a portage across the Alleghenies, engineers of the United States Army, sent out to choose the best route for a road across this same watershed, ran its line less than a mile below the one he had suggested.

Another great water transportation project which he foresaw and the route of which he sketched, was the Erie Canal, a line of travel now utilized also by the New York Central Railroad.

Applications of Engineering Knowledge

Having begun his life work at the age of 16 as a surveyor, Washington made use of that experience and his engineering knowledge at many different times during his later years. There was, for example, his lumbering operation in the Dismal Swamp, an expanse of spongy and flooded lands near Norfolk, Virginia. Again, on his western trip in 1784, Washington went to what is now Berkeley Springs, West Va., to witness the demonstration of one of Rumsey's early experiments in propelling a boat with steam. His support and interest resulted two years later in the success of Rumsey's steamboat on the Potomac and, in 1792, a similar triumph on the Thames in England—all of which antedated Fulton's famous trip with the Claremont on the Hudson.

Washington, a devotee of farming, lived at a time when agricultural implements were crude and unsatisfactory. To his active and resourceful mind this was a challenge which resulted in his devising an improved plow, inventing a drill, designing a new kind of threshing floor for his barns and, in the last years of his life, setting up a threshing machine which was a big improvement on the apparatus then used by the planters.

Plans for Bicentennial Celebration

The engineering profession, in view of all this, will naturally take a deep interest in the plans for the Bicentennial now being perfected by the United States George Washington Bicentennial Commission. This Commission, created by a special act of Congress in 1924, has as its chairman President Hoover. Its personnel includes prominent members of Congress and eight distinguished men and women representing the various sections of the country. Its executive officer is Congressman Sol Bloom of New York, with the title of associate director.

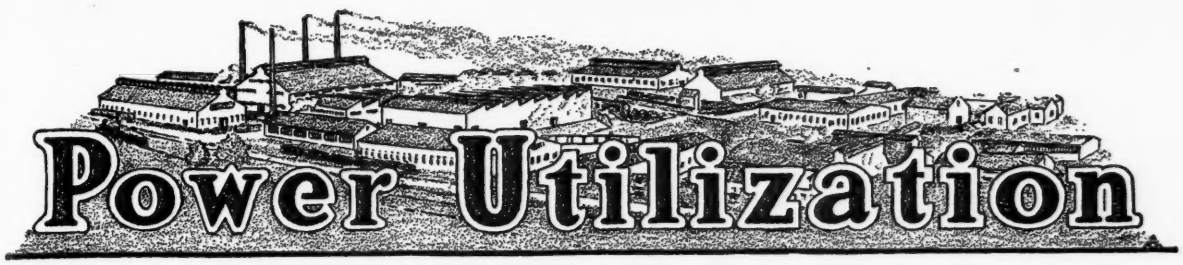
"Our plans," said Director Bloom recently, "do not contemplate any sort of entertainment that will attract the public to one place exclusively. To make the Bicentennial celebration truly nation-wide, we are taking it to the people, asking them to stage in their own home towns the appropriate exercises.

"The celebration period will last from February 22, 1932, until the following Thanksgiving Day. Within this time each community will have its ceremonies and festivities on a number of patriotic dates. This Commission furnishes free of charge the manuscripts of plays, playlets and pageants, each telling a story about Washington's experience and all of them expressly written for the Bicentennial celebration. Diplomats accredited to Washington have already informed us unofficially that the foreign countries will participate in the event. American citizens residing abroad have effected their organizations to plan appropriate exercises. February 22, 1932, the opening day of the celebration, will be marked, we hope, by the broadcasting of an inspirational address on Washington by President Hoover. This will be followed by a mammoth chorus singing the Star Spangled Banner, accompanied by the United States Marine Band. By means of a gigantic hook-up, Americans, wherever they may be, will hear the national anthem and join in the singing of it."

To date 43 states and more than 600 cities and smaller towns of the Union have appointed their Bicentennial Commissions to coöperate with the Federal body and to assume responsibility for the success of the commemoration in their respective territories. Any community which has not already made its plans for the celebration, will get valuable help in the work by applying to the United States George Washington Bicentennial Commission, Washington Building, Washington, D. C., for its comprehensive list of suggestions as to how Bicentennial exercises can best be staged.

Methods for preventing freezing of outdoor storage water tanks include steam radiator coils between tanks and sheathing, heating electrodes immersed in the tanks, warm water from a heater pumped into the bottom of the tank, hot air bubblers discharging into the bottom of the tank.

Trash on rack bottoms, growths on the inside of penstocks, trash on the wicket gates, worn bearings and eroded runners, cause losses in hydraulic plants not evident from a superficial inspection.



Flow-Meter Practice

Uses, Arrangement and Advantages

By George D. Conlee*

EVEN THOUGH early flow meters were crude and subject to all the troubles of a developing industry, their indications were of real value and many operating men found them of great assistance in maintaining efficient plant operation. After 20 yr., manufacturers are familiar with the requirements for accurate results. Some certain conditions prevent accurate metering but these conditions are so well known that it is seldom anyone tries to do the impossible.

Fluids Measured and Ranges Covered

Probably the measurement of steam comes first in both the number of meters in use and the value of the fluid measured, steam at all pressures, from 20 in. of mercury vacuum to 1800-lb. pressure, both saturated and superheated, being measured successfully. Up to about 600-lb. pressure, standard meters are used but for higher pressures, each installation is treated individually with due regard to valves, fittings, orifices and meter bodies.

Water, both hot and cold, is measured at all pressures up to 1200-lb. pressure with standard meter installations. There is really no limit to the pressure at which water can be measured but, above 1200-lb., special equipment is required and each installation has to be carefully engineered.

Air is measured under a gage pressure of a few inches of water, or even at pressures of a few inches of water below atmosphere, the upper limit being only the pressure to which air is compressed. The temperatures at which air may be measured are limited only by the materials available for the making of orifices; likewise for other gases. There is a large field of development in the measurement of natural gas as well as coke oven gas, blast furnace gas and still gas. Some of these are chemically active, hence care must be taken to use in the design of the meters only metals that are free from attack.

While the applications mentioned are for fluids that are comparatively clean, measurement of dirty fluids such as sewage, raw gases and powdered coal is demanded. With proper care, all of these conditions can be handled satisfactorily.

It is characteristic of all flow meters that they will read high when measuring a pulsating flow, that is, when the flow in the pipe line is in a series of puffs as in the discharge from reciprocating air compressors, steam supply to and exhaust from steam engines, discharge from water pumps. The effect of the pulsations on the accuracy depends upon the magnitude and frequency of the pulsation, also on the shape of the pressure curve. There is no predicting the magnitude of this error and the only remedy is to place the meter at a point where the pulsations have been greatly reduced. A receiver with one or more throttling orifices between the source of pulsations and the meter will usually reduce the pulsations to a point where reasonable accuracy will be obtained.

FIG. 1. STANDARD RECORDER-INTEGRATOR PANEL

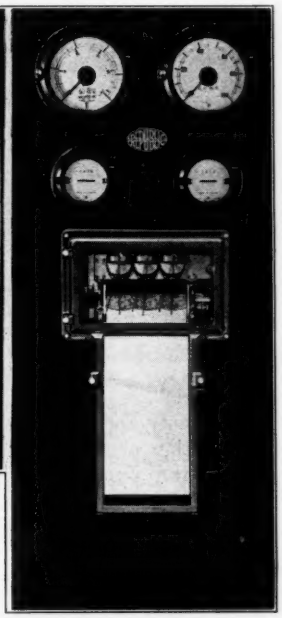


FIG. 2. MULTIPLE RECORDER SHOWS TWO FLOW RECORDS, CO_2 IN GASES, PRESSURES OR TEMPERATURES AS REQUIRED

Purposes of Metering

When considering installation of meters, it is always well to determine definitely the reason, or reasons, for the installation because, with this clearly in mind, it becomes a simple matter to select instruments that will give all the information required. Panel arrangement of recorder and integrator is quite generally used, Fig. 1, the panel being 16 by 24 in., suitable for two-high assembling.

*Chief Engineer, Republic Flow Meters Co.

Nearly any installation of meters will fit into one of six broad classes. As a usual thing, the installation as a whole, will come under one heading while separate meters may come under some of the other classes:

1. Accounting for cost distribution between various departments.
2. Check on the efficiency of operation of all power generating or using units.
3. Distribution of load between various units in order to maintain operation at the most efficient point.
4. Record to show that automatic equipment is operating properly.
5. Control of supply of steam or other fluid for process work in accordance with a predetermined program.
6. Check of consumption against total supply to detect any leakage or improper use.

and temperature are desired, the multiple recorder, Fig. 2, is provided. On the 12-in. strip chart, two pens can be used on each zone, giving six records. The panel has two indicators, two integrators and a multiple recorder.

Of course, all of these records must be studied carefully and allowance made for changed conditions over the period of operation. In any case, the meter serves much the same purpose as a cash register in the corner grocery store and it is much more important, because large values of steam or coal are being used. Unless some check is put on steam generation and consumption, there is no real knowledge of the efficiency of operation. It is absolutely impossible to judge steam generation, or steam consumption, without some sort of meter to record the facts.

Somewhat different is the use of flow meters to get proper distribution of the load among several boilers

FIG. 3. EACH BOILER HAS ITS PANEL OF TYPE SHOWN IN FIG. 2

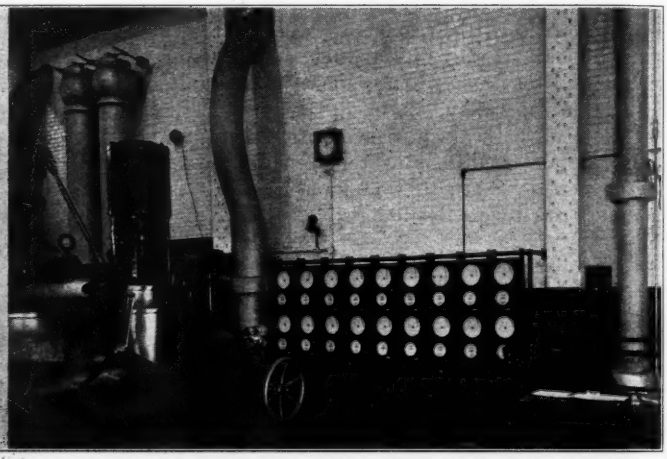


FIG. 4. METER PANELS OF TYPE SHOWN IN FIG. 1, GROUPED FOR CONTROL OF 18 BOILERS

Possibly the most common reason for an elaborate installation of meters is the demand for data for cost accounting purposes, to make possible charging each department with the actual amount of steam, water or any other service supplied. With the past custom of arbitrary charge, based on hours of operation, man-hours or units of production, there was no inducement to economy, because the charge was the same, regardless of care or carelessness. With exact charges, a premium is placed on good management and the savings that result are often large. Installation of meters, generally shows some surprising cases of miscalculation. Certain departments have been overcharged and certain others undercharged, the undercharges usually more in error than the overcharges.

Boiler and Engine Performance

An important use for meters is to check the efficiency of prime movers and boilers, as a continuous record of steam per kilowatt generated by a steam turbine is a direct record of the condition of the machine. The same is true of a boiler record of steam produced per pound of coal; that is, the evaporation is a direct indication of the condition of the boiler unit. This continuous checking of efficiency makes it possible to remedy defects at once, instead of waiting for a periodical overhauling. Where several records, such as steam flow, CO_2, pressure operating in parallel. When load is unevenly distributed, efficiency is less than when each one carries its fair share. When meters are put on a battery of boilers, wide variation is usually found of the rate of steaming for the several boilers. One or two will be running at a rate well below the average demand, several will be at just about the right point, while one at least will be running above the average with consequent high maintenance costs.

Department and Process Control

When meters are first installed on boilers, an unexpected condition is often found which causes accusation that the flow meters are incorrect. The fact is that, when three or four boilers are on the same line with a constant demand, there is always a hunting of the individual boilers; the output from one boiler goes up and the output from some other boiler goes down a corresponding amount. By means of meters, this hunting can be greatly reduced and better efficiency obtained. Convenient arrangement of a panel for each boiler is shown in Fig. 3, grouped arrangement in Fig. 4.

Checking the steam demand of departments and staggering operations so that peak demand in several departments does not occur at the same time, obviously will better economy. It is axiomatic that best boiler efficiency is obtained when the correct number of boil-

ers are on the line, with each boiler carrying its share of the load.

One important use for flow meters that is developing rapidly is to control chemical or mechanical processes, as in cooking of various materials. Probably the best known is the cooking of pulp in digesters for the making of paper. In cooking operations heat is required, furnished by the steam admitted. This heat develops gas which results in a pressure greater than that corresponding to the temperature. The gas is relieved from time to time, hence a record of steam flow, pressure and temperature is important. Pressure and temperature can be obtained from a separate recording instrument or they may be included in the flow meter record, so that all three records appear on the same chart and are properly synchronized. Usually no two cooks use exactly the same system of cooking; one will obtain better results than any of the others. By choosing the best method and then standardizing it, the results have been further improved to the point where definite cooking schedules are used; in fact, some companies have a definite form of curve for varying conditions of wood, the cook being required to admit steam in accordance with this standardized curve.

As to leakage, in cases where all plant water is measured at the pump house and again measured at the various consumptions, unless the two totals agree within a few per cent, there is either leakage or unknown use. In one case where the total pumpage is measured in a 60-in. line when it leaves the pump house, there are twelve or more distribution meters and the two totals customarily check within two per cent. This same arrangement of meters is used for keeping track of steam distribution in a number of plants, Fig. 5, and gas is similarly measured in steel mills.

Accuracy to be Expected

Customary guarantee for meter accuracy is that the error in the readings shall be not over plus or minus 2 per cent at all rates of flow between maximum capacity and 25 per cent capacity. Below 25 per cent capacity, the probable error increases to about plus or minus 5 per cent down to 15 per cent meter capacity, although positive guarantees as to accuracy are seldom made for any flow below 25 per cent of capacity. These guarantees apply to standard meters with orifices installed in pipes in the usual manner. When demands for extreme accuracy warrant the additional expense, it is possible to furnish meters with a guaranteed accuracy within plus or minus 1 per cent for flows down to 25 per cent of maximum.

It should be borne in mind that meter accuracy guarantees are based upon percentage of actual flow at each point and not percentage of maximum capacity of range, as is often the case with other kinds of instruments. For example, at a flow of 25 per cent of the meter capacity the guaranteed accuracy is 2 per cent of this, or 0.5 per cent of the meter capacity.

Proper Installation

All determinations of the coefficients for orifices have been made under ideal conditions, that is, in smooth straight pipes with no bends ahead of the orifice to cause eddies or swirls in the fluid approaching the orifice. This is usually covered in any meter guarantee by the statement "there must be straight line flow in the pipe at the point of measurement." It means that, in order for the calculations to hold, the actual conditions must approach as nearly as possible to the ideal conditions under which the coefficients were determined.

In general, it is customary to expect satisfactory results when there are twelve diameters of straight pipe ahead of the orifice and one diameter following, before any change in direction of flow occurs. Usually long radius bends, such as occur at outlets to boilers are considered equivalent to straight pipe. Sometimes with high velocities, this arrangement does not work out but the trouble is probably due to the nonreturn valve, which generally is placed at the inlet to the bend.

Such conditions can always be remedied by the use of so-called straightening vanes six or more diameters ahead of the orifice. These straightening vanes are a

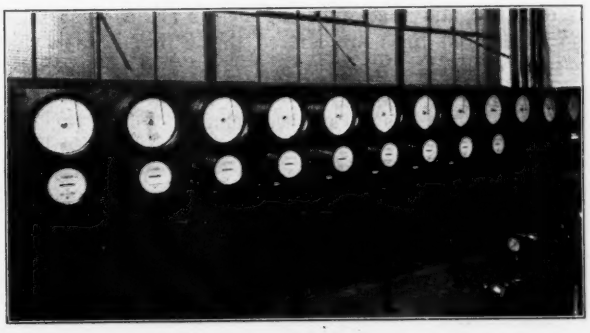


FIG. 5. METERS CHECK STEAM GENERATED, DISTRIBUTION TO DEPARTMENTS, CO_2, FLUE GAS TEMPERATURE AND NATURAL GAS USED IN SHOPS OF A RAILROAD

cellular device, one pipe diameter long, which break up the flowing stream into a number of streams that flow parallel after leaving the vane. The real difficulty is caused by a rotary motion in the pipe rather than difference in velocity at different points in the cross section of the pipe and the vanes eliminate such rotation. Angle valves, nonreturn valves, globe valves, tees and any Y fittings distort the flow and should be considered when locating an orifice.

In flow measurements, any change in the density of the fluid passing through the orifice requires the application of a correction factor, if accurate results are to be obtained. Any change in pressure or temperature of superheated steam causes a change in the density and the correction factor is proportional to the square root of the change of density. In the case of gases, changes in specific gravity, pressure, temperature or humidity all change the weight per cubic foot or density of the flowing gas. In the case of water, the only thing that affects the density is a change in temperature, a change so small for the temperature variations usually experienced that it is customary to neglect corrections. From the above, it is obvious that the measurement of water is the simplest problem, while the measurement of gas is the most complicated.

When measuring high-pressure steam, there is seldom great pressure variation, consequently, except for test purposes, corrections for pressure variation are seldom made. The same is true for temperature variations in superheated steam.

Low-pressure steam used for heating is subject to wide percentage variation in pressure so that corrections must be made, if accurate results are to be obtained. For this purpose, a pressure compensator has been developed, which automatically corrects all of the instrument readings for change in steam pressure. It is almost impossible to correct meter readings accurately from a pressure chart, if there is any wide variation in pressure. A correction factor must be used which is a weighted average of the square roots of the periodical pressure readings. This is too complicated for every day operation. The pressure compensator makes it possible to obtain accurate readings direct. The pressure compensator is also used with gas meters, particularly in the supply of natural gas, where pressure variations are large, so that unless proper correction is made, large errors are introduced.

A complete installation of flow meters requires some planning to make sure that a satisfactory installation is obtained and that sufficient meters are used so that no unmetered lines are left to throw doubt upon the results obtained. Where a system of meters has been installed and proper attention paid to their records, a material saving has always been made.

Pulpwood Handled by Power

STORING PULPWOOD for paper making into piles and rehandling it to the mill have long been troublesome operations, attended by considerable danger to workmen.

Early in 1927, Joseph Warren, mill manager of the S. D. Warren Co., took up with James B. Phillips, president of the Maine Electric Co. the possibility of machine handling, and pulling the pulpwood on and off piles by the drag scraper which was considered as the most feasible method. Experimental operations were started at the Cumberland Mills but not until December, 1928, was a successful equipment developed. After that, tests were made over a period of a year to determine capacity, power consumption and costs of maintenance and operation.

Early in 1930, a complete pulpwood rake outfit was installed at the new Bucksport plant of the Maine Seaboard Paper Co., essentially the same as that used at the Cumberland Mills of the S. D. Warren Co. Storing was started in August and Dec. 1, a pile of over 55,000 cords had been built. Reclaiming was then carried on, 350 cords a day, using one operator.

Performance has, therefore, proved successful over a period of 2 yr.

Equipment of Rake

This is constructed of steel, a structural frame, covered with plate and electrically welded throughout. Three sets of double teeth are pivoted separately for grappling the wood sticks so that action is the same, with either surface in contact with the wood.

Two sizes are made as follows:

	Large	Small
Weight, lb.	8400	5400
Length	33 ft.	26 ft. 6 in.
Width	10 ft.	7 ft.
Penetration of teeth	4 ft. 4 in.	2 ft. 9 in.
Capacity, storing	1.5 cords per trip	0.75 cord per trip
Capacity, reclaiming	2.0 cords per trip	1.0 cord per trip
Rope pull, lb.	15,000	8,000

Haulage is by a double-drum, band friction hoist. Frictions are single bands; each clutch is operated independently by remote control with heavy coil spring to set it and General Electric Co.'s hydraulic operator release. At the operator's station are small electric controls for each hydraulic operator, also stop and start buttons for the hoist motor. The haulage unit is made in several sizes for different rope pulls and speeds, with motors of synchronous-speed, squirrel-cage type, the power depending on speed and pull desired, but all designed for safe overload of 50 per cent under continuous service.

RAKE STARTING FROM TAIL SHEAVE TO STACK PULPWOOD

Rope System

Rope of plow steel, 6 strands, 19 wires each around a hemp center are used, the size proportioned to the needed pull. All sheaves have diameter at least 30 times the rope diameter and are mounted with Hyatt off piles by the drag scraper method was considered as

Head or pulling tower is made traveling or stationary, high or low, up to 100 ft., depending on conditions. Usually it is of the traveling type, 40 to 70 ft. high, with heavy concrete counterweighted base. It carries the haulage equipment, operator's cab and two head sheaves for leading out the rake ropes.

Tail tower is of lighter construction, to carry the tail sheaves which return haul ropes to the head tower. In many cases, these sheaves can be either anchored to deadmen posts set in the ground or bridled up onto the pile from such deadmen.

From experience, it is found that the head tower should be the same height as the desired storage pile and the tail sheaves should be located at least half the height of the finished pile above the ground.

For carrying sticks to the mill, cable conveyor and chain conveyor have been used, the former proving more satisfactory, as it keeps the wood moving, well spaced and requires no attendance for operation.

As the rake is in fact a drag scraper, it has inherent flexibility which makes possible a simple application for this use. Pulpwood is the largest bulk of material handled at a paper mill, hence a substantial investment in handling equipment is reflected in reduced cost of paper making.

For the two installations, at Cumberland Mills and Bucksport, data of the equipment are given in the accompanying table.

DATA OF PULPWOOD RAKE INSTALLATIONS

	Cumberland Mills of S. D. Warren Co.	Bucksport Mills of Maine Seaboard Paper Co.
Storage piles, number	3	1
length, ft.	425	500
width, ft.	200	400
height, ft.	50—60	60
capacity, cords	16,000 ea.	65,000
Kind of wood	4-ft. peeled poplar	4-ft. peeled and rough spruce
Equipment		
Stacker, height, ft.	70	50
Capacity, cords per hr.	80	75
Both cantilever, traveling type, double chain.		
Rake,		
Capacity cords per hr.		
Storing	90	90
Reclaiming	120	120
Ropes, diam., in.	1	1
Strands	6 by 19	6 by 19
Pull, lb.	13,000	15,000
Speed, ft. pr. min.	400	400
Head Tower, height ft.	50	65
Motor hp.	225	200
Tail Tower	two deadmen for sheaves	two 30-ft. on tracks
Conveyors, V trough steel armored	chain with plates	cable with buttons
Capacity, cords per hr.	80	75

Electric Crane and Hoist Maintenance*

BY ROBERT W. WALTON**

MAJOR POINTS in crane maintenance are lubrication, inspection, renewal of worn parts and keeping adjustments correct. Common to all cranes and hoists, however details may vary, are motors and controls, cables, gearing, wheels and runways.

Hoisting motors need more frequent attention than other parts due to greater use and that they are "plugged" when lowering and when spotting load. Daily inspection and care should be given slip rings, controller brushes and contacts. Ropes of floor controls should be renewed before they become frayed and only wooden handles used to avoid injuries from iron handles swinging head high.

Current conductor wires must have contacts free of dirt, ice, corrosion and loose connections, if power is to be reliable. When acid fumes are prevalent, equipment should be enclosed fume-proof if possible, otherwise be coated with cup grease to prevent corrosion.

Gears and bearings should be lubricated with grease or oil of the kind and at the intervals specified by the crane makers.

CABLES

Hoisting cables are exposed to injury and their proper condition is essential to safety, hence inspection and care must be vigilant. They should be kept well lubricated and, if subject to acid fumes or salty air, coated with grease. They should be so adjusted as to run always in the drum grooves and renewed as soon as wear or broken wires make necessary. While conditions vary, a good general rule is to replace a cable when it shows six or more broken wires per foot, or three adjacent strands broken, or outer strands worn ⅓ through.

Collars and sockets should be so attached that strands do not become untwisted or subject to unequal tension. For sockets, the hemp center should be cut out of the end, ends of strands turned inwards and thoroughly fastened with half and half solder to prevent pulling out of the socket.

BRAKES

Manufacturers' printed instructions are the best guide in maintenance of brakes. Electric and foot brakes should be so adjusted that they do not drag when in released position, or brake bands will burn. At the same time, the air gap of electric brakes must be small enough so that the armature will lift when current is on or the brake will likely burn out the brake coil.

Incorrect phase connection may reverse the motor, cause the limit switch to be inoperative and the blocks to collide or load to droop. In a 2-phase, 3-wire system, it may even result in burned out motors.

RUNWAYS

These must be kept in line and end bumpers squared to them or the crane will work badly and be distorted. Monorails when used for heavy load and high speed may require rails on the bottom flange of the beams to avoid frequent renewals. It should be remembered that, while small radius curves can be used, they will cause worn trolley wheels and track. For high speeds, 400 to 600 ft. a min. as now used, curve radii should be as large as possible.

Using hoists for side pulls is bad medicine. It results in cable wear, drum injury, broken limit switch levers, skewed cranes and strained runways. While sometimes apparently a convenience, it is costly practice.

Finally, it is better to put maintenance responsibility on one department, whether mechanical or electrical, and let help be asked as needed rather than take the chance of neglect of some part and buckpassing when trouble arises.

*From a paper before the National Industrial Congress, Cleveland, Ohio.

**Service Dept., Shepherd-Niles Crane & Hoist Corp.

Roof Made Effective Cooling Service

POSSIBLY somebody will be installing a new cooling system for a old machine or will be installing a new machine and a new system with it. A novel idea was worked out in one plant and observed recently by the writer, a description of which may be of interest.

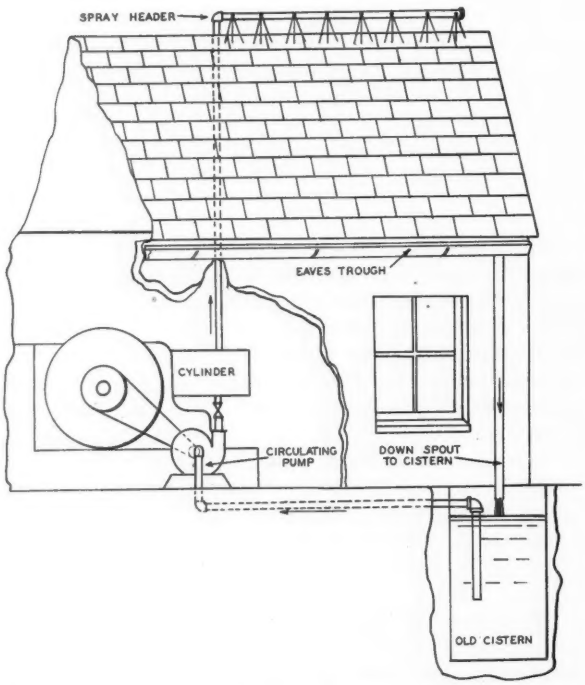


DIAGRAM OF COOLING SYSTEM MAKING USE OF A TILE ROOF AS THE COOLING SURFACE

An ingenious mechanic had installed a compressor in a building at quite a distance from the main part of the plant. Water was available at the site, but there was no way of connecting it with the main cooling system without running quite a long pipe line.

To cool the compressor and let the water run to waste was too wasteful, so he had belted a small rotary pump to a pulley on the compressor shaft, run the discharge pipe from the pump into the bottom of the water jacket, out at the top, and through the roof where it connected to a long pipe which ran along the ridge.

This pipe along the ridge was drilled full of holes and the water allowed to spray on the tile roof. The building had been spouted and the spouting led into an old cistern. The suction of the pump was run into this cistern well towards the bottom which completed the circuit and quite effectually cooled the water. The accompanying sketch shows a layout diagram of the system.

Coffeyville, Kan. P. A. GETT.

Steam Velocities in Piping Systems

THAT RULE OF THUMB for steam pipe sizes, at the bottom of page 621, June 1, seems just a little bit rough to be of a great deal of service. For high pressures and temperature of superheated steam, it is satisfactory up to a certain size but for engines and wet steam it might lead to complications and dangerous conditions of water hammer. For instance, a velocity of 12,000 ft. per min. would be out of all proportion for a 12-in., low-pressure heating line and if the steam is the exhaust from an engine or turbine of 90 to 95 per cent quality, it would be bound to cause dangerous vibration from water hammer and if there were many bends, it would probably crack some of them.

Turbine steam velocities can run much higher and it seems to be good practice to let the velocity run up to a maximum of 12,000 to 14,000 ft. and even higher with the high pressures now in use. For engines, unless they are multicylinder high speed, I think the velocities should not be over 8000 or 9000 ft., at most for fairly high pressures and considerable superheat. For low superheats or wet steam, I think that 6000 ft. is plenty to allow. Of course when high-pressure steam is throttled to low-pressure, you can run the velocity up considerably higher, as I have been told that some of the steam heating companies in their street mains use velocities as high as 50,000 and 60,000 ft. and pay little attention to velocity but control pressures carefully. Of course throttling or wiredrawing prevents any possibility of the steam being wet and as every B.t.u. drop means about 2500 ft. per min. velocity, it is seen that a very small pressure drop will give high velocities. The velocity in feet per second is equal to 223.8 times the square root of the heat drop.

In a paper presented before the American Society of Mechanical Engineers about 10 yr. ago, Mr. Broido gave figures that I have always felt were safe to follow.

I keep watch of some of the new plants that go up and where the sizes are given, I find that the same figures are still being followed closely. He says that for straight pipe sections and 300 to 500 lb. gage 10,000 to 12,000 ft. per min. is advisable for lines of over 5 in. if the steam flow is continuous. With engines, lower velocities should be chosen depending upon the length of the line, speed and cutoff. When the engine is located some distance from the boilers, it might be advisable to make the pipe near the engine larger than that near the boiler so as to dampen the fluctuations.

If the line has many fittings or bends, velocities should be lower because of excessive pressure drops. But even with this, velocity that can be used is almost twice that given at the bottom of page 621 with a 5-in. pipe. Friction losses are of importance only when power is to be made and process steam can be run at higher speeds if the steam is dry. Saturated steam velocities in commercial lines run, he says, around 3000 to 6000 ft. and any higher speed increases danger of water hammer and vibration. Another thing that he does not mention is that high velocities sometimes cause noise and it is necessary to hold it down in some places because of this. I have had lines that squealed but have never had anything to give any clew as to what velocity was necessary; it is about the same as sometimes happens in a reducing valve.

At Hell Gate, velocities of 15,000 to 20,000 ft. were used, according to Mr. Lawrence in discussing Mr. Broido's paper. The maximum velocity he thought should increase with the size of the pipe and he gave figures that amount to the same thing as the rule on page 621 up to a maximum of 15,000 regardless of the size of pipe, but he was speaking of the comparatively high pressure and temperature steam used in a central station with turbines and I believe that most of those who would have use for the rule given would have occasion to use it on low or medium pressure and wet steam and might get into trouble.

Brooklyn, N. Y. P. F. Rogers.

Tools for Recessing Commutator Mica

When recessing commutator mica, it is often difficult to confine the saw to the mica only. To overcome this difficulty, I recently designed the guide shown in the accompanying diagrams. The guide which is illustrated in Fig. 1 is made of a strip of thin sheet brass, flexible enough to bend around the commutator and long enough to cover it completely.

The strip is cut in half and fitted with flanges and the wing nuts D, so that it can be bolted to the commutator. A steel hoop B is made and riveted to the fixture as shown. Next take a hack saw and carefully cut the slot C in the fixtures; this must be exactly square with the two ends. The fixture can then be bolted on the commutator. If it has been correctly made, the slot in the fixture should run exactly in line with the micas and with a little trimming will be exactly their size. When cutting down mica, this fixture can be bolted on the commutator and the slot arranged parallel with the mica, which can be cut down without fear of cutting the copper.

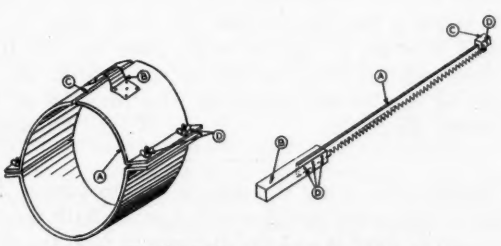


FIG. 1. FIXTURE FOR RECESSING MICA
FIG. 2. SAW FOR CUTTING MICA

For hand slotting, a suitable tool can be made from an old hack saw blade. Figure 2 shows a recessing tool I have found useful. It contains a piece of hack saw blade A fitted into a handle B, the method of fitting being to cut a slot in the handle in which the blade fits loosely and then secure it by the three set screws D. At the other end of the saw a second handle C should be fitted so that pressure may be put on the far end of the saw. Both handles are made of wood. This enables blades to be quickly changed. It will be seen that these fixtures enable both hands to be used, besides completely protecting the copper.

Herts, England. W. E. Warner.

Improving Power Factor In the Plant

Because of the success attained in improving the power factor at the plant in which the writer is employed, it was thought perhaps that other readers of this magazine might get some worthwhile thought from our experience.

Our connected load of approximately 500 hp. consists of induction motors ranging from fractional to 50 hp. in size. Some of these drive individual machines and others drive lineshafts such as is typical of large industrial machine shops, pattern shops, foundries, etc.

Our system power factor averaged about 60 per cent and as a result of this low power factor, we were paying a penalty of 1½ per cent for each lump of 5 per cent, our power factor was below 80 or, in other words, 4 times 1½, which is 6 per cent of our total power bill; this amounted to a monthly penalty of 6 per cent of $700, or $42 a month, or $504 a yr. We were not primarily interested at the time to increase the capacity of our system, but had in mind eliminating this penalty charge. We, however, were in need of a standby generator which could be driven by a steam engine which we had, therefore, we decided upon a synchronous motor to give us power factor correction and also to be belt driven by the steam engine to generate current to drive induction motor connected to blower on our cupola to prevent a possible freeze in case the city current was off for appreciable length of time. The motor used was a 100-hp., 80 per cent leading power factor with exciter generator directly connected on main shaft with a regular pulley on opposite end of motor shaft.

Since this installation, we have not had to use it as generator, but have found that running it idle, without any mechanical load, we have boosted our power factor up to 80 per cent, thereby eliminating all penalty charge and resulting in a saving to us from $40 to $50 a month and, since the initial cost of this equipment, including installation cost, was only ap-

proximately $2,000, the saving will retire the cost in 4 to 5 yr. and the balance of 11 to 15 yr. of expected life will be a net saving to our company of approximately $5544 to $7560, to say nothing of the value of having a standby generator.

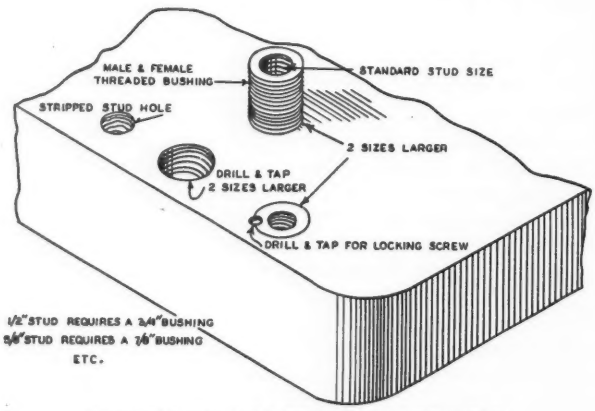
Had we been needing additional capacity in our plant, we could have added approximately 160 kv-a. load on our system without any additional current flowing in the system as compared with original conditions.

Various kinds of apparatus can be used for correcting power factor, however, due to the ability of a synchronous motor to be driven as a generator or carry a mechanical load and still correct power factor, it will in general be found to be the most desirable and economical way of correcting power factor. Where it is not practical to utilize these features of the synchronous motor, the static condenser can be used to correct large blocks of power factor or the power factor of individual motors or groups of motors. The method will best be determined after careful expert study of conditions of the particular case and the results obtainable. The choice should then depend upon the net returns on the investment together with better voltage regulation.

San Antonio, Tex. R. H. PARRISH.

Repair of Stripped Stud Hole

IT IS NOT ALWAYS possible to weld a layer of new metal conveniently in a stripped stud hole in the casting of a cylinder or steam chest, pump chamber and the


MALE & FEMALE THREADED BUSHING
STANDARD STUD SIZE
STRIPPED STUD HOLE
2 SIZES LARGER
DRILL & TAP 2 SIZES LARGER
DRILL & TAP FOR LOCKING SCREW
1/2" STUD REQUIRES A 3/4" BUSHING
5/8" STUD REQUIRES A 7/8" BUSHING
ETC.

BUSHING REPAIRS STRIPPED STUD HOLE

like. It is a simple task, however, to put in a steel bushing as shown in the accompanying sketch and often to make the job stronger than before.

Most plants are equipped with the necessary tools to do this sort of job. First the stripped hole is drilled to take a tap two sizes larger than the original tap size. Next the steel bushing is threaded outside to fit the enlarged tapped out hole and tapped inside to fit the original stud. This bushing is screwed in and locked by a key or dowel screw as shown and the job is completed.

Concord, N. H. CHAS. H. WILLEY.

AFTER OBTAINING the correct fuel and lubricating oil for a Diesel plant, too much care can not be exercised in storing and handling them.

Manholes In Horizontal Return Tubular Boilers

NOT LONG ago a man squeezed through the manhole in the front head of a 60-in. horizontal return-tubular boiler. While he was inside, the man's bulk increased due to heat and humidity. For a time it looked as if an oxy-acetylene cutting torch would have to be brought into play to get him out but a liberal dousing with cold water finally enabled him to emerge. Had the major and minor dimensions of the elliptical hole been made half an inch larger, which the general dimensions of the boiler would have warranted, both entrance and exit would have been easy.

Many boilers of this type are in use that have no adequate means of access to the space beneath the tubes, so that thorough cleaning and inspection are difficult. If the boiler is of small diameter, say 42 in. or less, and is correspondingly short, a good-sized handhole beneath the tube-ends in the front head is, of course the best that can be expected. But in boilers of larger diameter and proportionately longer, safety and economy demand that there be provided a hole large enough for a slender man of not over 150 lb. weight to slip through easily. Otherwise it is practically impossible to remove effectively the accumulation of loose scale and mud that may become lodged in the region of the blowoff orifice.

Boiler manufacturers seem to have been of several minds regarding the minimum size of shell that should take a manhole, instead of a handhole beneath the tubes. The purpose of dispensing with a manhole in the lower part of the front head is to provide room for an extra row of tubes and so increase the steaming capacity of the boiler. This, however, appears to be a case in which the loss overbalances the gain, for the increase of heating surface offered by the additional tubes hardly compensates for the difficulty of cleaning the water surfaces of the tubes and adjacent shell plates.

Inasmuch as the products of combustion tend mostly to pass through the upper tubes, whatever abridgment of the heating surface might result from leaving out enough tubes to accommodate a manhole in the lower part of the front head would diminish the efficiency of the boiler but little. On the other hand, it would afford untrammeled water circulation over the fire sheets. At any rate, free opportunity for cleaning and inspection ought to be one of the main considerations in designing a steam boiler.

St. Louis, Mo. D. J. ALTIZER.

Oiling Out-of-the-Way Oil Holes

IN SOME power plant machinery the oil holes are situated in very inaccessible positions where it is impossible to get a full size oil can. In these cases the best method is to get a length of wire, place one end in the oil hole and the other in the oil can mouth. By this means oil can be run down the wire into the oil hole.

Herts, England. W. E. WARNER.

MECHANICAL WORK is equal to the product of force times the distance through which it acts. With the force measured in pounds and the distance in feet, the resulting unit of work is the foot-pound.

Questions and Answers

Hogged Fuel

WE ARE OPERATING two h.r.t. heating boilers of about 120 hp. each, burning hogged fuel, mostly shavings and sawdust. We were advised to close the stack dampers just to the point where the boilers wouldn't smoke in order to get all the heat out of the gases and save fuel. Operating in this way, it is difficult to keep a steady steam pressure and the flues became coated with a hard scale almost impossible to remove with a flue scraper. In another plant of about the same boiler capacity also using wood waste for fuel, we left the stack dampers wide open and did not experience scale on the tubes.

During the last two weeks, we have left the stack dampers wide open and controlled the fire with the ashpit doors and the fuel lid on top of the dutch oven. The firing has been much easier, the pressure is easily controlled with no apparent increase of fuel consumption and the flues have not taken on any additional coating of scale. I would like to know whether the scale was caused by dampering too much with the stack dampers; whether it was caused by the fuel or by a combination of both. D. C. G.

A. Accumulation of slack on boiler tubes where hogged fuel is used, sometimes occurs, usually from fuel carried over by excessive draft. This results in secondary combustion. The deposit usually is fluffy and easily removed and can be stopped by reducing the draft to the point where the fuel carryover stops. In the present case, the fuel you use may have a high pitch content and cutting down the draft by closing the damper results in the stratification so that the heavy gases are carried over and condensed on the comparatively cool tubes before they can be brought in contact with sufficient oxygen to burn them completely. The action is probably the same as that in the formation of soot in a coal burning furnace.

Opening up the damper and increasing the draft, particularly with over fire air, increases the furnace turbulence and results in more complete combustion. The absence of definite data regarding the moisture content of the fuel, the draft, CO_2 and extra gas temperature, it is difficult to draw definite conclusions. It would be well to install a draft gage, CO_2 instrument and flue gas thermometer so as to check the actual operating conditions and in this way determine the best way to regulate the draft and air. The damper wide open may give too much air and cause fuel carry over so it is probable that a partial closing of this stack damper with supplementary control of the air by the ashpit door and over fire air will give the best operating conditions.

EDITOR'S NOTE: Perhaps other readers have had similar difficulty with hogged fuel so that they would be in a position to offer suggestions as to the proper method of operation.

High Head Pressures

CAN YOU suggest some remedy for the high head pressure in our refrigerating plant? Condensers are clean, with no scale, and they are cool, with the exception of the top coil in each of the seven stems. The balance of the coils are as cool as the return water to the tower. There are approximately 90 ft. of 1¼-in. pipe to the receiver and the fall is approximately 30 in.

A. B. J.

A. Several things may be wrong. The condensers may be partly filled with liquid; there may be considerable air or other noncondensable gases in the ammonia, or the water may not be flowing freely. With so much of the condenser cool it is likely that the liquid is not draining properly to the receiver.

A number of common condenser troubles and their remedies are enumerated in the article "Ammonia Condensers—Their Care and Operation," by C. T. Baker, on page 565 of the May 15, 1931 issue. We would suggest that you first make sure that there is no pocket which prevents the condenser from draining properly and then purge the condenser and receiver of foreign gases.

In a plant in good condition, the pressures should not be more than 2 or 2½ lb. higher than saturation temperature of the ammonia corresponding to the temperature of the water leaving the condenser. According to Dalton's Law of Partial Pressure, the presence of air or noncondensable gases will increase the head pressure by the pressure which these gases would exert if they occupied the space alone. For instance, if there was enough air in the receiver to cause a pressure of 10 lb. when the receiver was empty, this air pressure would be increased to 20 lb. when the receiver was half full of ammonia and with a saturation temperature of ammonia of say, 160 lb., the total pressure in the receiver would be 160 plus 20 or 180 lb.

Steam Pressure in Absorption Systems

WHAT TEMPERATURE of steam must be maintained in the generator of an absorption system to reduce the strong aqua from 38 to 28 per cent concentration and still maintain a temperature difference of 10 deg. between the steam and the temperature of the weak liquor leaving the generator? Temperature in the ammonia condensers is 88 deg. F. A. H.

A. A condenser temperature of 88 deg. F. corresponds to an ammonia pressure of about 160 lb. gage. Assuming the same pressure in the generator as in the condenser, a 28 per cent aqua solution at 160 lb. gage boils at 236.5 deg. F. Adding 10 deg. to this will give the steam temperature of 246.5 deg. which corresponds to a steam pressure of 13.3 lb. per sq. in. gage.

Editorial Comment

Power Under Fire

Power, especially electric, seems to be a favorite target for politicians whose ambition has growing pains. Just why electric current should be a more logical subject for regulation, taxation and bureaucratic interference than steel making, coal mining or automobile manufacture is not evident except that public utility executives by wise, progressive management have kept their business in comparatively good financial position during the present business slump.

The public has been larruped with pseudo statistics and statements of $500,000,000 to $650,000,000 excessive profits from householders and the public necessity for electric power. As has been pointed out, total receipts from domestic customers are only some $650,000,000 a year, hence the profits stated as excessive would imply that current should be furnished free. Average cost per day for families using current is about 10 cents, so that, even if current were furnished free by government plants, the reduction in family expense would be inappreciable.

As to necessity for current in the home, thousands of farm homes are getting on comfortably without it. As current becomes available to them, it is found of sufficient convenience and economy to justify its use at present rates, which have been steadily reduced when other costs of living were increasing.

Steel, coal and automobiles are regarded as necessities by many families but are not used by others. Yet no wild outbursts are heard against the large combinations of steel makers, coal mine operators or automobile manufacturers as potential ogres which will develop a strangle hold on government.

Bureaucratic control and operation of industries, here and in other countries, creates no encouragement for optimism as to better results under such control than under free private operation. That some state public service commissions have seemed to feel undue influence, at some times from utility corporations, at other times from political pressure, is but an indication of the actions to be expected of a federal bureau.

Another barrage that is being laid down is the tax on current, which has been assessed in several states and proposed in others. If, as some of the political artillerymen claim, electric current is an essential, in the same class as food, meat, milk and clothing, what is the basis for taxing one essential, thus adding to its cost to consumers, and not the others? The tax is collected from the producer but must appear in the cost of the product. Why not tax the farmer a tenth of a cent a quart on milk he sells or a half cent a pound on cattle, sheep and pigs sold for market? And why should the householder and small power user have a tax added to his current cost while the manufacturer who uses enough power to make it profitable to generate it himself or the user who buys from a municipal plant escape?

Probably there are instances of unfair accounting and unjustifiable profits in the case of some holding and utility companies, as there are cases of unjustifiable charges by some hotels for accommodations. Since hotels are essential to those who travel, political snipers might as well shoot at the hotel owners, many of whom have combination chains, to try to put the hotels into the bag for government regulation, tax and ownership.

Increased use of power is aiding industrial production and relieving drudgery in house and farm work. Political gunmen who are harrassing such development, trying to make personal capital by their activities, are comparable to the old time raider chiefs who started wars for personal glory with no regard to the welfare of their countries or the subjects they were supposed to protect. Demagogs appeal to mass psychology for immediate personal ends. Statesmen study the lessons of history to learn the means for permanent advancement of public welfare.

Power Production Is Still a Good Business Barometer

Somehow it is extremely difficult for us to believe that the country has gone entirely to the dogs, as we look thoughtfully at the summary of electric power produced for public use in the United States in 1930, recently issued by the U. S. Geological Survey, which shows a total of 95,936,000,000 kw-hr. for the year. Somebody apparently bought and used those kilowatt-hours and it is fair to assume that most of them were paid for within 30 days, as we have heard of no installment plan for the purchase of kilowatt-hours out of income.

But our musings are rudely interrupted by a shriek of "Look! Look! The total production for 1930 was less than it was for 1929!" Well, yes, it was—1.5 per cent less, to be exact. We refuse to become excited about that, however, because we prefer to look at the number instead of at the minus sign. If that were 20 per cent less, for example, instead of 1.5 per cent, it might be something to worry about.

The insignificance of that 1.5 per cent decrease in 1930 is indicated by a little closer analysis of the data. The total production for public use in 1930 was 95,936,000,000 kw-hr. In 1928 the total production was 87,850,000,000 and 1928 was a good year. Furthermore, of the total for 1930, 33,021,000,000 kw-hr. or 34.4 per cent were produced by water power, a decrease of 4.6 per cent from the 1929 production while 62,915,000,000 kw-hr., or 65.6 per cent of the total, were produced by fuel, an increase of 0.3 per cent over the 1929 figures. Much of the decrease in production by water power can be accounted for by shortage of water in certain localities.

The plants making power for public use in 1930 include: central stations producing 89,951,758,000 kw-

hr.; electric railways, 2,777,485,000 kw-hr.; steam railways, 699,438,000 kw-hr.; Bureau of Reclamation, 145,053,000 kw-hr. and that part of the electric power produced by manufacturing plants that is sold, 1,443,345,000 kw-hr.

In these plants, the consumption of coal and the coal equivalent of other fuels continues its downward trend. The average consumption of fuels for these plants for the year was 1.62 lb. per kw-hr., or 51 per cent of the rate obtained in 1919, as compared with 1.69 lb. per kw-hr. in 1929, which was 53 per cent of the 1919 rate.

Another interesting fact shown by the report is that the consumption of gas has increased from 112,707,000,000 cu. ft. in 1929 to 120,290,000,000 cu. ft. in 1930, or 6.7 per cent. Consumption of fuel oil has decreased 8.5 per cent but the total amount of power made with coal, oil and gas has increased approximately 0.4 per cent.

In the light of these figures, even though they do not include the amounts of power produced in industrial plants, it is difficult to generate any great amount of pessimism as to the soundness of the power industry. Inasmuch as the entire industrial structure is based on that industry, it would seem that there must be more general business than many people believe and that it is not the part of wisdom to regard the low values of certain stocks and the depression of some of our large industrial corporations as the sole indicators of the country's condition.

When business was at its peak in 1928 and 1929, the power business was taken as a most effective business barometer in preference to certain other industries. Why abandon this barometer now, when we run into difficulties? The navigator at sea does not throw away his barometer in the midst of a storm. He watches it carefully because it may give him an indication of better weather ahead.

Industrial Improvements

Most power plant engineers realize the importance of insulation, particularly when high temperatures are involved. This is not true in many industrial applications, however, and reports of steel men on this subject at a recent A.I.M.M.E. meeting are of interest. Speaking of insulation of blast furnace regenerators (air heaters)and industrial furnaces, doubt existed in the minds of some engineers as to the practicability of building furnaces with insulation even though it seemed theoretically advisable.

As an experiment to see whether furnaces could be run successfully with an insulated roof, one company daubed plastic insulation from 2½ to 3½ in. thick on a furnace while it was operating. Radiation loss was greatly reduced but more important, this furnace has been found to require less repairs than any of the others. The company is convinced that all furnace roofs should be insulated.

The story is but half told, however, because, after the insulation was installed, it was found impossible to heat up the furnace without causing the roof to buckle and come down. Fortunately, a helper watching the roof closely had sufficient initiative to change the operating routine and eliminate this trouble.

Another company reported an outside roof temperature of 1700 deg. but considered that it did no harm. Another with more foresight insulated the roof, speeded up the furnace considerably and saved 4 to 5 gal. of oil per ton of steel. Another company also reported 4 to 5 gal. saving of oil with no operating changes and a third as high as 10 gal. of oil, although this saving included other changes made at the same time. Several others reported from 5 to 10 per cent fuel saving, greatly increased capacity and reduced maintenance.

Insulation usually requires both construction and operation changes, however, and those wide-awake companies with sufficient initiative and ability to make the changes will profit. Those who follow the path beaten by others will remain in the rear with the man who could see no harm in a 1700-deg. furnace roof.

Improvements call for changes. The automobile was an improvement on the horse but it was necessary to change from hay and oats to gasoline and oil in order to make it work. Those individuals who felt that they could simply apply insulation to furnaces without changing their fixed routine were disappointed. Those who had intelligence enough to make changes to meet the new condition are reaping the benefit.

Blind application is not sufficient in any field; the successful person is the one who takes an idea and works it over to meet his conditions. To men of this type we owe our progress. With the keen competition which is to be expected during the next few years, reduced production costs are a vital necessity and it is up to those who can think to find new and more efficient ways of using and conserving heat, light and power, vital elements of practically all industries.

Industrial Plant Location

Location of industrial or manufacturing plants is a matter of great importance which demands consideration of many factors and good judgment. An error in location is practically permanent as it is extremely costly to relocate.

Because of the multitude of factors involved, it is impossible to lay down general rules beyond specifying that the best location is where the combined cost of production and distribution of the product can be maintained at a minimum. Two general phases must be considered. First, the section of the country and second, the specific site in the selected territory.

In practically all industries, an ample supply of fuel and power must be assured. It is extremely difficult to tabulate requirements and arrange them in relative importance, although this can be done in specific cases. For instance, in the location of a certain rolling mill, economic factors were given the following value: Fuels and power 430; labor 250; living conditions 100; construction cost 20; supplies 60; transportation 50; climate 50; taxes and laws 20; water supply 10; site 10.

In this particular case, fuel and power were rated at 430 out of a possible 1000; that is, these two items were practically as important as all other considerations combined.

ACCIDENTS result in decreased production, increased labor turnover, lower morale, material spoilage, property damage and often loss of life.

Power Plant Engineering Developments and News

Multiple Disc Magnetic Clutch

MULTIPLE DISC magnetic clutch, designed to eliminate difficulties previously inherent in large size clutches, has been developed by the Magnetic Manufacturing Co., Milwaukee, Wis. It is built to provide maximum horsepower, greater pull-out-torque and the usual advantages of smaller magnetic

MAGNETIC CLUTCH WITH HIGH PULL-OUT TORQUE

clutches by way of ease of operation, smooth acceleration and low maintenance cost. The installation cost is also appreciably less, it is claimed, than that of the usual large clutches.

A typical clutch is illustrated here. With a 24-in. diameter, over 6500 ft-lb. pull-out-torque can be developed; ample friction lining is provided for low pressure and resulting long life. The pressure per square inch is low and the clutch provides desired greater slippage.

Style E Powercoater

STYLE E POWERCOATER, to be used in the application of Apexior to the internal tube surfaces of water-tube boilers, has recently been developed by The Dampney Co. of America, Hyde Park, Boston, Mass. This Powercoater is claimed to be not only an improvement over previous models but also less expensive. It is used as an attachment to the ordinary boiler tube cleaner, as shown in the accompanying cut.

When coating straight tubes, the Powercoater is attached to the tube cleaner with a rigid coupling; a Universal Coupling is used for bent tubes. The Powercoater consists of two short arms mounted in a circular base, which open out in a V formation by centrifugal force. Two removable bristle brushes with die cast backs are fastened to the ends of the arms by means of pins with split ends. The freedom of movement of the arms in the base, and of the brushes on the arms, allows for the adjustment of the brushes to the surface of the tube, as the Powercoater opens out in the tube due to rotation of the air-driven turbine tube cleaner. The brushes

Powercoater Equipment
For Applying APEXIOR Coatings to Internal Tube Surfaces

Typical Powercoater supplied by Dampney Company — PATENTED — Tube Cleaner and Air Hose supplied by Customer

STYLE E POWERCOATER FOR APPLYING APEXIOR

pick up the liquid Apexior which has previously been deposited in the tube and thoroughly brush and scrub the coating into the surface of the metal. The Apexior thus forms a thin smooth coating over the entire internal tube surface which dries quickly and which is intended to make the surface impervious to any action of the hot water and steam in contact with it.

Pipe Wrench

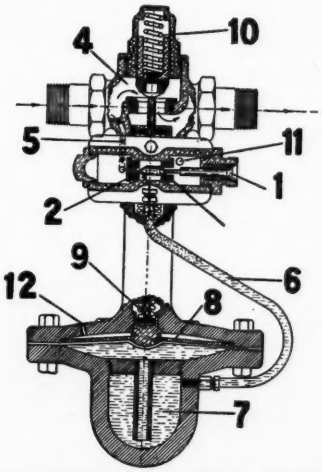
DESIGNED to be a husky wrench for husky men, the new Walco Pipe Wrench, recently developed by Walworth Co., Boston, Mass., is shown in the accompanying view. It has only four parts: the bar of drop forged tool steel, incorporating the jaw housing; the drop forged tool steel jaw; the nut, with a raised surface on either side of the knurl to protect it from battering and the alloy steel spring made to give double action on the jaw and to be easily replaced without tools. Jaw threads have rounded crests to resist damage and to avoid jamming inside the nut. Teeth of jaw and bar are of new design to give quick certain grip and are heat treated to give correct hardness and strength.

NEW WALCO PIPE WRENCH

Temperature Regulator for Intermittent Service

FOR INTERMITTENT SERVICE with pressures from 5 to 125 lb., the Sarco Co., Inc., 183 Madison Ave., New York, N. Y., has developed the Sarco temperature regulator Type TR-24, built in from ½ to 1½ in. sizes. This regulator is of the indirectly operated type where the thermostat actuates a small pilot valve which admits the pressure to a large area diaphragm. This diaphragm, in turn, operates the main valve.

Main regulator valve is of the single seated, overbalanced type, held tightly to its seat, in the closed position, by a powerful spring. In operation, the main valve is either wide open, or closed tightly. The regulator,



SARCO CO., INC., TYPE TR-24 TEMPERATURE REGULATOR

therefore, is especially well adapted for intermittent service, where no additional heat is required over long periods, as, for example, in hot-water service for wash rooms or showers; for adding live steam to the exhaust in feedwater heaters, or similar applications.

While this valve will not throttle, the regulator is extremely sensitive, since the thermostat merely opens and closes a small pilot valve, always of the same size, regardless of the size of the main valve. Close control of temperature is the result. Since the main valve is opened by line pressure and closed by a spring, the valve will close if the line pressure should fall below the required minimum operating pressure of 5 lb., thus protecting the thermostat against overheating.

Stem of the main valve is packless, being sealed by a Sarco seamless corrugated bellows. There are no stuffing boxes to leak or stick. The seats, both of the pilot and of the main valves, are made of hard nickel alloy and renewable. The disc of the main valve is asbestos composition and also renewable.

Assuming a standard Sarco thermostat as for TR-21 attached at 1 and inserted in the apparatus to be controlled, and assuming that the temperature of the medium is below that for which the thermostat is set—then pilot valve 2 will be open and exhaust valve 3 will be closed.

Steam (or other heating medium) entering the main valve 4 in the direction of the arrows, passes through port 5, valve 2, tube 6 into diaphragm chamber 7, thus raising diaphragm 8. Valve stem 9 is thus pushed up, opening main valve 4 and compressing spring 10. When the desired temperature is reached, the thermostat closes pilot valve 2 and opens the exhaust port 3.

The pressure under diaphragm 8 is then exhausted through tube 6, exhaust valve 3 and exhaust port 11 to atmosphere or a drain line not under pressure. Spring 10 then pushes the main valve 4 closed and steam pressure being on top of disc holds it closed.

As soon as the controlled apparatus requires further heat, the thermostat will reopen pilot valve 2 and another cycle of operation will begin. The chamber 7 with its tube connecting to the diaphragm chamber, furnishes a reservoir which assures that only cool water can come in contact with diaphragm 8. A small vent hole 12 relieves air and maintains atmospheric pressure on top of diaphragm 8.

Compensated Temperature Instrument Tubing

TO ELIMINATE possible error in the functioning of temperature instruments, due to external temperature conditions surrounding the tubing connecting the bulb to the instrument itself, Taylor Instrument Cos. of Rochester, N. Y., have produced a new type of capillary tubing in which the compensating qualities have been incorporated in the material of the tube itself.

Essentially the new method consists of so proportioning the volume of mercury in the tubing to its coefficient of expansion and to the size of the alloy wire, that any change in the volume of mercury, resulting from external temperature changes, is accurately compensated.

TEMPERATURE INSTRUMENT WITH NEW COMPENSATED TUBING

For this reason, the adjustment is made for each varying exposure and it is not necessary to compensate the instrument for the average external condition along the length of the tubing, a difficult, if not impossible adjustment to make.

This new 7/32-in. compensated tubing, combined with the rugged welded joints and the bulb of machined alloy steel, is designed to be a most sensitive and lasting temperature responsive element.

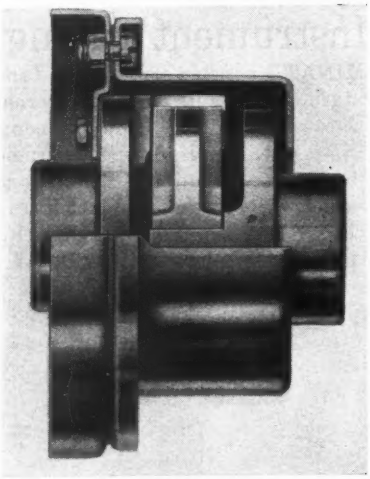
Cross-Type Couplings

NEW DESIGN of cross-type Franke flexible coupling, as shown, has recently been placed on the market. Particular features of this new design are stated to be: greater capacity for axial or out of center misalinement; the limit stop, when the free hub contacts against en-

closing case, to prevent operation too far out of line; simplicity and ease of installation; continuous lubrication but requires no more lubricating attention than the usual ball bearing; once or twice a year.

The two forged steel flanges with prongs and the lightweight center cross are similar in many respects to the Oldham coupling, used for many years in general industrial service. The pressed-steel enclosing grease case provides an adequate reservoir for lubricant and moving parts are thus continuously lubricated.

The clearance hole at end of grease case is to permit as much as $\frac{1}{16}$-in. axial or out of center misalinement and this grease case also acts as the limit stop. When the clearance is equal all around the hub, then the shafts are in good alinement and this casual check can be made without disturbing coupling or machines. The two flanges of grease case can be separated for a more accurate check of alinement or to pack with grease. For usual installations, ordinary cup grease should be used;



SECTIONAL VIEW OF COUPLING WITH SHAFTS MISALINED

for higher temperatures, a somewhat harder grease should be used. The new coupling is made by Smith & Serrell of Newark, N. J., in sizes with maximum bore from 1⅛ to 1⅞ in. and horsepower ratings from 1½ to 15.

News Notes

THE ELLISON DRAFT GAGE CO. of Chicago announces the appointment of Craun-Liebing Co., 30 Euclid Arcade, Cleveland, Ohio, as exclusive representative in the Cleveland territory including northeastern Ohio.

C. L. SAUNDERS, for over 14 years in charge of publicity for Morse Chain Co., Ithaca, N. Y., retired from active connection with the company on April 1. For 10 years he was active as consulting engineer in power plant construction for hospitals, office buildings and schools and, later served as research engineer for National Carbon Co. He is planning an extended vacation, after which he will resume consulting work on publicity and organization of industries.

R. D. BEAN, formerly manager of the Engineering Development Department of The Brown Instrument Co., Philadelphia, has been made chief engineer of that company.

AMERICAN ENGINEERING CO. has secured contract for water walls to be installed in a furnace designed for combination pulverized coal and wood refuse firing at the No. 1 Plant of the Fisher Body Corp., Flint, Michigan, to operate at 300 per cent of rating and at 200 lb. gage pressure.

The side and uptake walls will have bare tubes backed up with suitable plastic refractory and insulation, to give freedom from excessive smoking at low ratings, reduction of refractory maintenance, high steaming capacity and efficiency, while the entire water-cooled surface will be enclosed by a gas-tight steel casing.

WITH THE CREATION of a bureau, announced by President F. A. Merrick to exercise control over all printing matters affecting the Westinghouse Electric and Manufacturing Co., A. B. Zerby was appointed manager of the Printing Bureau. A printing bureau is an innovation to industry but its activities will provide added efficiencies, economies and simplification in the work under Mr. Zerby. The duties of the new bureau, he states, will be to receive and analyze all printing requisitions from all sources, prepare specifications for printing, select satisfactory sources of supply, specify methods and process that are to be used and to supervise printing production. Mr. Zerby, a graduate of Pennsylvania State College, has been associated with Westinghouse advertising activities since 1912, the year he completed the Westinghouse Graduate Student Course. In 1920 he was appointed executive assistant to the general advertising manager and in 1929 was made director of advertising production.

UNION CHAIN & MFG. CO., Sandusky, Ohio, has recently announced the appointment of the Industrial Gear & Machine Works, 225 Sixth Ave., Oakland, Calif., as exclusive distributors for its products in that territory. The principals of the western company are W. I. Brown and P. E. Haultain, who will handle sales.

AT THE HOTEL MADISON, Atlantic City, N. J., on June 15, 16 and 17, the 45th Annual Session of the Supreme Council of the American Order of Steam Engineers was held.

THE IOWA RAILWAY & LIGHT CORP. will erect a $36,000 power plant to replace the one now located between Toledo and Tama, Iowa, and work will be completed Sept. 1, according to F. C. Chambers, Cedar Rapids, manager. Twenty bids were received for the construction contract. The plant will have three 1200-hp. Diesel engines with complete substation, providing 24-hr. service for the territory.

APPOINTMENT of Arthur T. Hunter as assistant sales manager —boiler division of the Riley Stoker Corp., Worcester, Mass., has been announced. Mr. Hunter is a graduate of Cornell University in Mechanical Engineering. Since 1923 he has been engaged in power plant engineering and sales engineering at St. Louis, Mo.

ILLINOIS STOKER CO., Alton, Ill., wishes to announce the appointment of Robert Lacey, 604 Chamber of Commerce Buildin, Pittsburgh, Pa., as its representative in that territory.

ANNOUNCEMENT is made by L. Mundet & Son, 461 Eighth Ave., New York City, that hereafter its selling organization throughout the United States of America will be operated under the name Mundet Cork Corp. It is further announced that there will be no change whatsoever in its sales policy although operating under the new name and that all transactions covered by Mundet Cork Corp. will be fully guaranteed, as in the past, by the parent company.

ANNOUNCEMENT has recently been made of the purchase of Eastern New Jersey Power Co. by the Jersey Central Power & Light Co.

FISHER GOVERNOR CO., Marshalltown, Iowa, announces the opening of a new branch factory in Los Angeles, Calif., under the immediate charge of Jasper H. Fisher, Chairman of the Board of Directors of the Fisher Governor Co. and Ray McCoy, factory manager, who for 18 yr. has been an inspector in the Marshalltown factory. Forest Wehrman of the accounting department in Marshalltown will have charge of the office and accounting department in Los Angeles.

ILLINOIS STOKER CO. of Alton, Ill., announces the establishment, on June 1, 1931, of the Illinois Stoker & Combustion Co., Ltd., Great Britain. The headquarters of this company is Atlantic House, 45-50 Holborn Viaduct, London, E. C. 1. Lowden Morton, who was formerly with the Vickers Boiler Co., of England, became managing director of the new company.

H. W. FOULDS, assistant to the president and general sales manager of Goulds Pumps, Inc., Senaca Falls, N. Y., recently announced several changes in the headquarters and branch office staffs of the company. Effective May 1, Henry L. Boyer was appointed manager of Farm-Suburban Sales; Henry F. Miller, manager of Industrial Sales; W. G. Allen, manager of Engineering Sales; J. B. Anderson, in charge of the Department of Inquiry and Estimate; G. W. Cramer, Advertising Manager. The following appointments in branch house organizations have also been made: Mark D. Rowe, formerly Eastern Manager, Servel Sales, Inc., now manager of New York office; J. B. Foley, formerly manager of Goulds Pittsburgh office, now manager of Chicago office, and Fred Jones, formerly connected with Goulds Philadelphia office, now manager of Pittsburgh office. The company has opened a new branch office at Dallas, Texas, 417 Magnolia Bldg., Fred Hayes, manager. This is in addition to offices maintained in Houston and Tulsa.

Books and Catalogs

LABORATORY TESTS of Reinforced Concrete Arches with Decks is the title of Bulletin No. 226 published by the Engineering Experiment Station of the University of Illinois, Urbana, Ill. The bulletin is the result of tests conducted by Wilbur M. Wilson in which by means of photographs, drawings and detailed experimental data are compared a number of different designs of concrete arches. One object of the investigation was to determine the behavior of a reinforced concrete monolithic structure consisting of a rib, spandrel columns and a deck and to compare the behavior of this composite structure with the behavior of a similar rib without columns or deck. The price of the bulletin is $0.50 but a number or copies are available for free distribution.

IN A NEW 16-page, letter-size bulletin, referred to as the black book, L. Mundet & Sons, New York City, give information and specifications for the installation of Mundet Jointite cork pipe covering under various conditions, together with price lists of the material. The bulletin shows how thick the insulation should be, lists the sundries that are needed in connection with cork pipe covering, shows what to do when pipes are close together and gives other engineering information.

IN A NEW 40-page, well-illustrated colored catalog, Yarway blowoff valves are described. Complete details and cross sections of the type A seatless valves, type C balanced seatless valves, and double-tightening valves and tandem seatless valves of various types are given. Tables of dimensions, list of parts, price list and description of details complete the bulletin. At the end are discussions of the floatless Hi-Lo alarm water column and the involute spray nozzle. This new bulletin is published by Yarnall-Waring Co., Chestnut Hill, Philadelphia, Pa.

SHUNT METER, type KS, for measurement of steam, air or gas is described and illustrated in new bulletin No. 255, by Builders Iron Foundry, Providence, R. I. The feature of the bulletin is the new expanded capacity table showing standard orifice sizes for both steam and air meters. Meters of these standard orifice sizes are kept in stock for shipment on short notice. Complete description is given of the meter and its principles of operation.

WHERE CONTROL MUST NOT FAIL is the title of a recent bulletin describing and illustrating applications of control equipment on cranes of all types, issued by the Electric Controller & Mfg. Co. of Cleveland, Ohio.

IN AN ATTRACTIVELY-ILLUSTRATED and well-designed 16-page bulletin, The Strong-Scott Mfg. Co. describes the opening of its new offices and manufacturing plant at the corner of Taft and Kennedy Sts., Minneapolis, Minn. This bulletin contains many good photographs showing manufacturing processes in the new factory and is designed to give a complete picture of all the activities of the company. Larson & McClaren were the architects of this new building and G. M. Orr & Co. was the consulting engineer.

HOW TO DEADEN MACHINE VIBRATIONS AND NOISE is the title of a bulletin recently published by L. Mundet & Son, 461 Eighth Ave., New York City. The bulletin shows and tells how machinery should be isolated by means of natural cork so that noise and vibrations will be eliminated. It gives a table of sizes and shapes of Mundet natural cork mats and shows curves of compression tests on mats 1½ in. thick and 3 in. thick.

COOPER-BESSEMER stationary type JT Diesel engine is described and illustrated in detail in a new bulletin issued by the Cooper-Bessemer Corp., Mt. Vernon, Ohio.

VOGT WATER-TUBE BOILERS are described in a 64-page attractively illustrated bulletin WT-3 just issued by Henry Vogt Machine Co., Inc., Louisville, Ky. This bulletin describes in detail the construction of Vogt boilers, shows many installations of them and contains line drawings of fittings, tables of capacities and dimensions and other engineering data.

CENTRIFUGAL pumps types LA and LC single stage volute type are described in new bulletins W-312-S4, S-7, S-8 and S-5 by Worthington Pump & Machinery Corp., 2 Park Avenue, New York City. Horizontal, duplex double-plunger steam pumps, outside-packed pattern are described in bulletin D-112-S-13. Industrial chromium plating as demonstrated by Worthington is discussed in publication S-2001-A which describes and illustrates many machinery parts thus treated.

WHITE GOLD is the title given to a booklet describing the evolution and purposes of the Hoover Dam on the Colorado River for which main contracts were recently awarded. It is an interesting treatment of the subject in popular form and well illustrated, issued by the American Steel & Wire Co., 208 So. La Salle St., Chicago, Ill., from whom copies may be obtained on request to the President's office.

NON-CLOGGING centrifugal pump for handling sewage and for application to many processes in industrial plants is described in a bulletin which has just been published by Morris Machine Works, Baldwinsville. N. Y. Among the illustrations are views of an assortment of objects such as blocks of wood, rags, clothing and sticks, which have passed through one of the pumps without clogging. The test curves of a typical pump are presented. These pumps are built for both horizontal and vertical shaft installations in a range of sizes from 3-in. to 42-in. and for any type of drive.

PUBLIC UTILITY POINTS is the title of a 16-page bulletin just published by Bonbright & Co., 25 Nassau Street, New York, in which are presented statistics regarding the financial and engineering operations of the public utilities in the United States up to the end of 1930.

INGERSOLL-RAND Solid Injection Diesel Engines is the title of a new bulletin issued by Ingersoll-Rand Co., 11 Broadway, New York City. It discusses the advantages of Diesel power and contains a general description of I-R Diesels ranging from 150 to 1200 hp.

BOILER WATER CONDITIONING is the title of a 16-page treatise just published by the Elgin Softener Corp., Elgin, Ill. This book, printed in two colors, discusses the various problems in the conditioning or treatment of boiler water. The book is profusely illustrated by pictures showing various types of scale and sludge, corrosion and pitting, embrittlement, with a large number of blueprints showing various methods of gravity and pressure feeds for chemical control, the application of sludge deconcentrators to typical types of boilers, the schematic arrangement of deconcentrator and heat exchanger and the zeolite-deconcentrator combination.

COPPUS HEAT KILLERS, which are motor driven fans of various capacities made portable so that they can be transported to different parts of the plant to supply ventilation to the workmen or processes as needed, are described in bulletin 160-3 just issued by the Coppus Engineering Corp., 344 Park Ave., Worcester, Mass.

MECHANICAL RELIABILITY OF HYDRO-ELECTRIC UNITS—1929 is the subject of publication No. 120 just issued by the Hydraulic Power Committee, National Electric Light Association, 420 Lexington Ave., New York City. This report discusses outage records of 235 units, covering a wide range of head and capacity, which have been classified according to the type of turbine and the cause of the outage. Data on reliability are tabulated and are also presented graphically to show trends and to make comparisons of the performance of steam and hydroelectric units.

MERCON liquid level controller is described and illustrated in Bulletin No. 4C just issued by the Mercon Regulator Co., 1 La-Salle St., Chicago, Ill.

SEVERAL NEW BULLETINS, bound in loose leaf form and entitled "Bacharach Instruments For Use in Engineering Schools" have just been issued by Bacharach Industrial Instrument Co., 7000 Bennett St., Pittsburgh, Pa. Bulletin 3294 discusses pyrometers and CO_2 meters; bulletin 3263 discusses engine indicators, Maihak type; bulletin 3132 describes a demonstration flowmeter set; bulletin 3131 describes manometers and inclined gages; 3092 describes airflow meters.

SPENCE REGULATORS are completely described and illustrated in a loose-leaf, letter-size publication No. 34-E-3 just issued by Spence Engineering Co., Inc., 110 East 42nd St., New York City.

WORK DONE in 1930 by United Engineers & Constructors, Inc., 125 E. 46th St., New York, is illustrated in a new booklet that contains a large composite drawing of the office buildings, industrial plants, power stations and other structures erected by the company, with the object of indicating the range and scope of its activities.

OIL BURNING IN POWER PLANTS is the title of a new 36-page bulletin issued by the National Airoil Burner Co., 1327 Girard Avenue, Philadelphia, Pa. The bulletin discusses first the details of oil burner installation, such as storage tanks, piping and the like, and then gives details of the National Airoil burner, method of using it, tables of capacities, oil consumption and data regarding its application. This company is also issuing bulletin No. 22, Installation Instructions for Steam Atomizing Oil Burning System for high pressure steam boilers, stills, dryers, and the like. Bulletin No. 30, another new publication, describes oil burning accessories for industrial and commercial oil burning installations. Bulletin No. 50 describes combustion units for use with oil and gas for high-pressure steam boilers, stills, dryers and industrial furnaces. Bulletin 60 discusses type I-R rotary oil burners for heating boilers and other furnaces. Bulletin 70 treats type D-R rotary oil burners and another new four-page bulletin entitled, "Oil Burning Efficiency" gives a brief comparative discussion of steam atomizing and mechancal atomizing of marine type oil burning systems.

Power Plant Construction News

Ala., Birmingham—The Estes Lumber Co., Vanderbilt Road, is said to be planning the installation of electric power equipment in connection with proposed rebuilding of portion of mill recently destroyed by fire with loss reported over $75,000, including machinery.

Ark., Murfreesboro—The Common Council is said to be planning the installation of pumping machinery and auxiliary equipment in connection with a proposed municipal waterworks. E. T. Archer & Co., New England Building, Kansas City, Mo., are engineers.

Calif., Pasadena—The Board of Trustees, California Institute of Technology, plans installation of electric motors and other power equipment in proposed new laboratory group, consisting of two three-story units, entire project reported to cost $500,000. Mayers, Murry & Philip, 2 West Forty-seventh Street, New York, are architects.

Fla., Fort Myers—The Florida Power & Light Co., Miami, Fla., has plans maturing for construction of a new transmission line from Fort Myers to LaBelle, about 26 mi., reported to cost close to $50,000.

Ga., Trion—The Trion Co., Trion, plans installation of electric power equipment in proposed new addition to cotton mill, entire project reported to cost more than $75,000.

Ind., Elwood—The Elwood Lumber Co., Elwood, is said to be planning the installation of motors and other electric power equipment in connection with a proposed new lumber mill to replace a plant recently destroyed by fire; entire project reported to cost close to $50,000.

Iowa, Lake Mills—The City Council has called a special election to approve plans for a municipal electric light and power plant to cost about $90,000, with equipment. It is expected to begin work at an early date.

La., Natchitoches—The Common Council has arranged a bond issue of $55,000 for extensions and improvements in electric light and water plant, including installation of additional equipment.

La., Shreveport—The Central & Southwest Utilities Co., Shreveport, has authorized plans for an addition to steam-operated electric power plant at Arsenal Hill, to increase present capacity by 18,750 kw. Extensions will also be made in transmission lines. Company engineering department is in charge.

Me., West Peru—The Berst-Foster-Dixfield Co., Dixfield, Me., has plans for a power house and pumping plant at wood novelty manufacturing plant at West Peru, reported to cost close to $50,000. H. F. Hallock, Oswego, N. Y., is architect and engineer.

Mass., Boston—The International Harvester Co. of America, Inc., 61 North Beacon Street, is said to be planning the installation of motors and other electric power equipment in connection with an addition to motor truck service and repair works at Brighton, estimated to cost about $75,000.

Mich., Grand Haven—The Ottawa County Board of Supervisors has authorized plans for a new central heating plant for county buildings, reported to cost over $40,000 with equipment. Byron Parks & Son, Grand Rapids, Mich., are engineers.

Mich., Wyandotte—The Pennsylvania Salt Mfg. Co., Widener Building, Philadelphia, Pa., is said to be planning the installation of electric power equipment in a new three-story addition to plant at Wyandotte, entire project reported to cost close to $50,000.

Minn., Bemidji—The City Council has called a special election on July 28, to approve a bond issue of $90,000, for the installation of a sewage treatment plant, for which plans have been prepared. Louis P. Wolff, Globe Building, St. Paul, Minn., is engineer.

N. J., Palmerton—The New Jersey Zinc Co., 160 Front Street, New York, plans installation of electric power equipment in proposed new zinc sulphide plant at mill at Palmerton, entire project reported to cost over $100,000. Company engineering department is in charge.

N. Y., Fredonia—The Eagle Canning Co., Fredonia, plans installation of electric power equipment in connection with proposed rebuilding of portion of food canning plant recently destroyed by fire with loss reported in excess of $50,000.

N. C., Marion—The McDowell Furniture Co., Marion, is said to be planning installation of electric motors and other power equipment in connection with a new addition to factory, entire project reported to cost over $50,000.

Ohio, Massillon—The Republic Steel Corporation, Youngstown, Ohio, plans installation of electric power equipment in proposed expansion and improvement program at its Enduro stainless strip steel mill at Massillon, entire project to cost close to $300,000.

Ohio, Toledo—The Department of Water, W. H. Schroeder, service director, plans installation of pumping machinery and auxiliary equipment in connection with extensions and improvements in water supply system to cost over $500,000. H. P. Jones & Co., Second National Bank Building, Toledo, are engineers. It is understood that bids will be asked early in August.

Okla., Supply—The State Board of Affairs, Capitol Building, Oklahoma City, Okla., will soon have plans drawn for a new power plant at Western Oklahoma State Hospital at Supply, estimated to cost about $85,000. W. C. Hughes is chairman.

Pa., East Warren—The Emblem Oil Co., Warren, is said to be planning the installation of pumping machinery in connection with new oil storage and distributing plant at East Warren, entire project reported to cost about $70,000.

Pa., Philadelphia—The Philadelphia Gas Works Co., 1401 Arch Street, has plans for an addition to artificial gas plant on Tioga Street, reported to cost over $65,000 with equipment. Company engineering department is in charge.

Pa., Platea—The Cook Brothers Lumber Co., Platea, is said to be planning the installation of electric motors and other power equipment in connection with proposed rebuilding of portion of plant and mill recently destroyed by fire with loss reported at over $60,000.

S. C., Aiken—The City Council is said to have plans maturing for a municipal electric light and power plant, and a referendum vote will be taken to approve the project. It is understood that a Diesel oil engine installation will be made. The Burns & McDonnell Engineering Co., Interstate Building, Kansas City, Mo., is engineer.

Tenn., Memphis—The Memphis Power & Light Co. has plans for a one-story steam-operated electric power plant on Payne Avenue, to cost over $100,000, with equipment.

Texas, Corpus Christi—The Southern Alkali Corporation, affiliated with the American Cyanamid Co., 535 Fifth Avenue, New York, is said to have plans maturing for a proposed new alkali plant at Corpus Christi, Texas, reported to cost close to $5,000,000. Project will include a power house. It is understood that the Pittsburgh Plate Glass Co., Grant Building, Pittsburgh, Pa., is interested in the enterprise.

Texas, Dallas—The Globe Oil & Refining Co., Cushing, Okla., is planning installation of power equipment in new oil refining plant now being projected in vicinity of Dallas, entire project reported to cost about $500,000. I. A. O'Shaughnessy is president.

Texas, Houston—The Shell Petroleum Corporation, Shell Building, St. Louis, Mo., and Tulsa, Okla. plans installation of booster pumping plants in connection with a new oil pipe line from Kilgore to Houston, about 200 mi., entire project to cost over $1,000,000.

Wash., Spokane—The Armstrong Machinery Co., 3201 East Riverside Street, is said to be planning installation of electric motors and other power equipment in connection with proposed rebuilding of portion of plant recently destroyed by fire with loss of more than $60,000.

W. Va., Parkersburg—The Parkersburg Clay Products Co. is said to be planning rebuilding of portion of power station, including engine room recently destroyed by fire with loss reported at close to $50,000, including equipment.

Wis., Ashland—The Pacific & Atlantic Coal Docks Co., Ashland, plans installation of electric power equipment in proposed new coal briquet manufacturing plant, entire project reported to cost more than $80,000.